Makkar (2012)

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Daten von Makkar (2012)

```
#Datensortierung

# In Mortalität umrechnen
makkar2012_r$V2 <- 100 - makkar2012_r$V2

makkar2012_r <- makkar2012_r[complete.cases(makkar2012_r),]

makkar2012_r <- makkar2012_r[order(makkar2012_r$V2), ]

# Werte außerhalb des Bereichs [0, inf] raus
makkar2012_r <- makkar2012_r[makkar2012_r$V1 >= 0, ]
xr_makkar2012 <- sort(makkar2012_r$V1)
yr_makkar2012 <- makkar2012_r$V2



# In Mortalität umrechnen
makkar2012_b$V2 <- 100 - makkar2012_b$V2

makkar2012_b <- makkar2012_b[complete.cases(makkar2012_b),]

makkar2012_b <- makkar2012_b[order(makkar2012_b$V2), ]

# Werte außerhalb des Bereichs [0, inf] raus
makkar2012_b <- makkar2012_b[makkar2012_b$V1 >= 0, ]
xb_makkar2012 <- sort(makkar2012_b$V1)
yb_makkar2012 <- makkar2012_b$V2
```

Startfunktion

Um die bestmögliche Anpassung an den vorliegenden Datenpunkten darzustellen wurde mithilfe einer Funktion der beste Startparameter mit dem kleinsten Fehler errmittelt, da die Anpassung stark von den initialen Startwerten abhängig ist.

```
find_best_start_2parameter <- function(p, q, max_beta, max_eta, steps_beta,
                                       steps_eta, fitting_function) {

  best_errors <- numeric()  # Vektor für Fehlerwerte
  best_starts <- matrix(nrow = 0, ncol = 2)  # Matrix für Startparameter
```

```
  for (beta in seq(0, max_beta, by = steps_beta)) {
    for (eta in seq(0, max_eta, by = steps_eta)) {
      start_params <- c(beta, eta)

      # Schätze die Parameter mit den aktuellen Startparametern
      if(identical(as.character(substitute(fitting_function)), "getstuexp2")){
        output <- capture.output({
        result <- getstuexp2(
                        p = p, q = q, start = start_params,
                        show.output = TRUE, plot = FALSE, wert1 = 2
                      )
        })
      }
      else{
        output <- capture.output({
        result <- fitting_function(p = p, q = q, start = start_params,
                                   show.output = TRUE, plot = FALSE)
        })
      }

      # Berechne den Fehler (makkar2012_r_1$value) für die aktuellen Startparameter
      current_error <- as.numeric(gsub("\\[1\\]\\s+", "", output[5]))

      # Speichere Fehler und die Startparameter, wenn der Fehler nicht NA ist
      if (!is.na(current_error)) {
        best_errors <- c(best_errors, current_error)
        best_starts <- rbind(best_starts, start_params)
      }
    }
  }


  # Finde den Index des kleinsten Fehlers (ignoriere NA-Werte)
  best_index <- which.min(best_errors)

  # Wähle den besten Startparameter mit dem kleinsten Fehler aus
  best_start <- best_starts[best_index, ]

  # Gib den besten Startparameter und den entsprechenden Fehler aus
  cat("Bester Startparameter:", best_start, "\n")
  cat("Bester Fehler:", best_errors[best_index], "\n")

  return(best_start)
}


find_best_start_3parameter <- function(p, q, max_shape1 = 10, max_shape2 = 10,
                                       max_scale = 10, steps_shape1, steps_shape2,
                                       steps_scale, fitting_function) {

  best_errors <- numeric()  # Vektor für Fehlerwerte
  best_starts <- matrix(nrow = 0, ncol = 3)  # Matrix für Startparameter
```

```r
  for (shape1 in seq(0, max_shape1, by = steps_shape1)) {
    for (shape2 in seq(0, max_shape2, by = steps_shape2)) {
      for (scale in seq(0, max_shape1, by = steps_scale)) {
        start_params <- c(shape1, shape2, scale)

        # Schätze die Parameter mit den aktuellen Startparametern
        if(identical(as.character(substitute(fitting_function)), "getstuexp3")){
          output <- capture.output({
            result <- getstuexp3(
                          p = p, q = q, start = start_params,
                          show.output = TRUE, plot = FALSE, wert1 = 2, wert2 = 6)
          })
      }

        else{
          output <- capture.output({
            result <- fitting_function(p = p, q = q, start = start_params,
                                show.output = TRUE, plot = FALSE)
          })
        }
        # Berechne den Fehler (makkar2012_r_1$value) für die aktuellen Startparameter
        current_error <- as.numeric(gsub("\\[1\\]\\s+", "", output[5]))

        # Speichere Fehler und die Startparameter, wenn der Fehler nicht NA ist
        if (!is.na(current_error)) {
          best_errors <- c(best_errors, current_error)
          best_starts <- rbind(best_starts, start_params)
        }
      }
    }
  }

  # Finde den Index des kleinsten Fehlers (ignoriere NA-Werte)
  best_index <- which.min(best_errors)

  # Wähle den besten Startparameter mit dem kleinsten Fehler aus
  best_start <- best_starts[best_index, ]

  # Gib den besten Startparameter und den entsprechenden Fehler aus
  cat("Bester Startparameter:", best_start, "\n")
  cat("Bester Fehler:", best_errors[best_index], "\n")

  return(best_start)
}




find_best_start_4parameter <- function(p, q, max_shape, max_scale, max_rate,
                                       max_mix, steps_shape, steps_scale,
                                       steps_rate, steps_mix,fitting_function) {

  best_errors <- numeric()  # Vektor für Fehlerwerte
```

```
  best_starts <- matrix(nrow = 0, ncol = 4)  # Matrix für Startparameter

  for (shape in seq(0, max_shape, by = steps_shape)) {
    for (scale in seq(0, max_scale, by = steps_scale)) {
      for (rate in seq(0, max_rate, by = steps_rate)) {
        for (mix in seq(0, max_mix, by = steps_mix)) {
          start_params <- c(shape, scale, rate, mix)

          # Schätze die Weibull-Parameter mit den aktuellen Startparametern
          output <- capture.output({
            result <- fitting_function(p = p, q = q, start = start_params,
                                       show.output = TRUE, plot = FALSE)
          })

          # Berechne den Fehler (makkar2012_r_1$value) für die aktuellen Startparameter
          current_error <- as.numeric(gsub("\\[1\\]\\s+", "", output[5]))

          # Speichere Fehler und die Startparameter, wenn der Fehler nicht NA ist
          if (!is.na(current_error)) {
            best_errors <- c(best_errors, current_error)
            best_starts <- rbind(best_starts, start_params)
          }
        }
      }
    }
  }

  # Finde den Index des kleinsten Fehlers (ignoriere NA-Werte)
  best_index <- which.min(best_errors)

  # Wähle den besten Startparameter mit dem kleinsten Fehler aus
  best_start <- best_starts[best_index, ]

  # Gib den besten Startparameter und den entsprechenden Fehler aus
  cat("Bester Startparameter:", best_start, "\n")
  cat("Bester Fehler:", best_errors[best_index], "\n")

  return(best_start)
}
```

Datenanpassung an die Daten von Makkar (2012)

Weibullverteilung

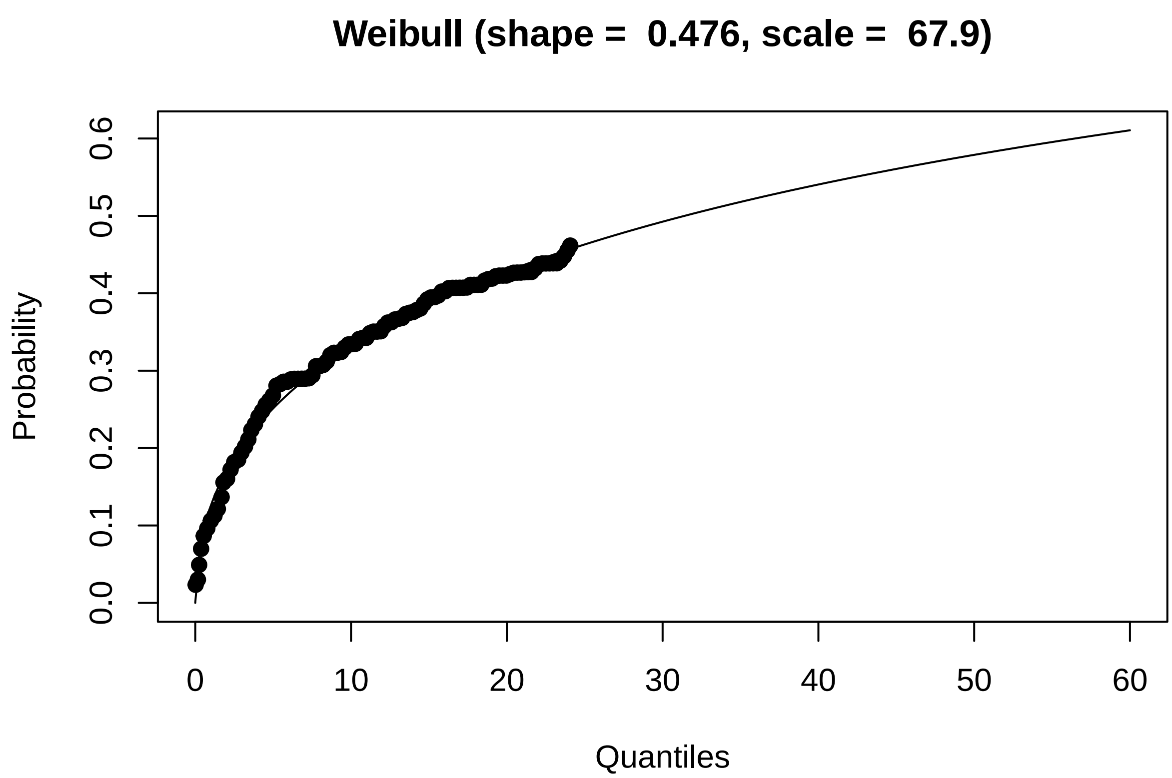
```
# Weibullverteilung
source("C:/Users/Chau/Documents/Masterarbeit/R Funktionen/getweibullpar.R")

best_makkar2012_r_1 <- find_best_start_2parameter(p = yr_makkar2012/100, q = xr_makkar2012,
                                                  max_beta = 10, max_eta = 10,
                                                  steps_beta = 1, steps_eta = 1,
                                                  fitting_function = getweibullpar)
```

```
## Bester Startparameter: 3 9
```

```
## Bester Fehler: 8.383571e-07
```

```
makkar2012_r_1 <- getweibullpar(
                        p = yr_makkar2012/100,
                        q = xr_makkar2012,
                        start = best_makkar2012_r_1,
                        show.output = TRUE,
                        plot = TRUE
                      )
```

```
## $par
## [1]  0.475537 67.866432
##
## $value
## [1] 8.383571e-07
##
## $counts
## function gradient
##       34       34
##
## $convergence
## [1] 0
##
## $message
## [1] "CONVERGENCE: REL_REDUCTION_OF_F <= FACTR*EPSMCH"
```

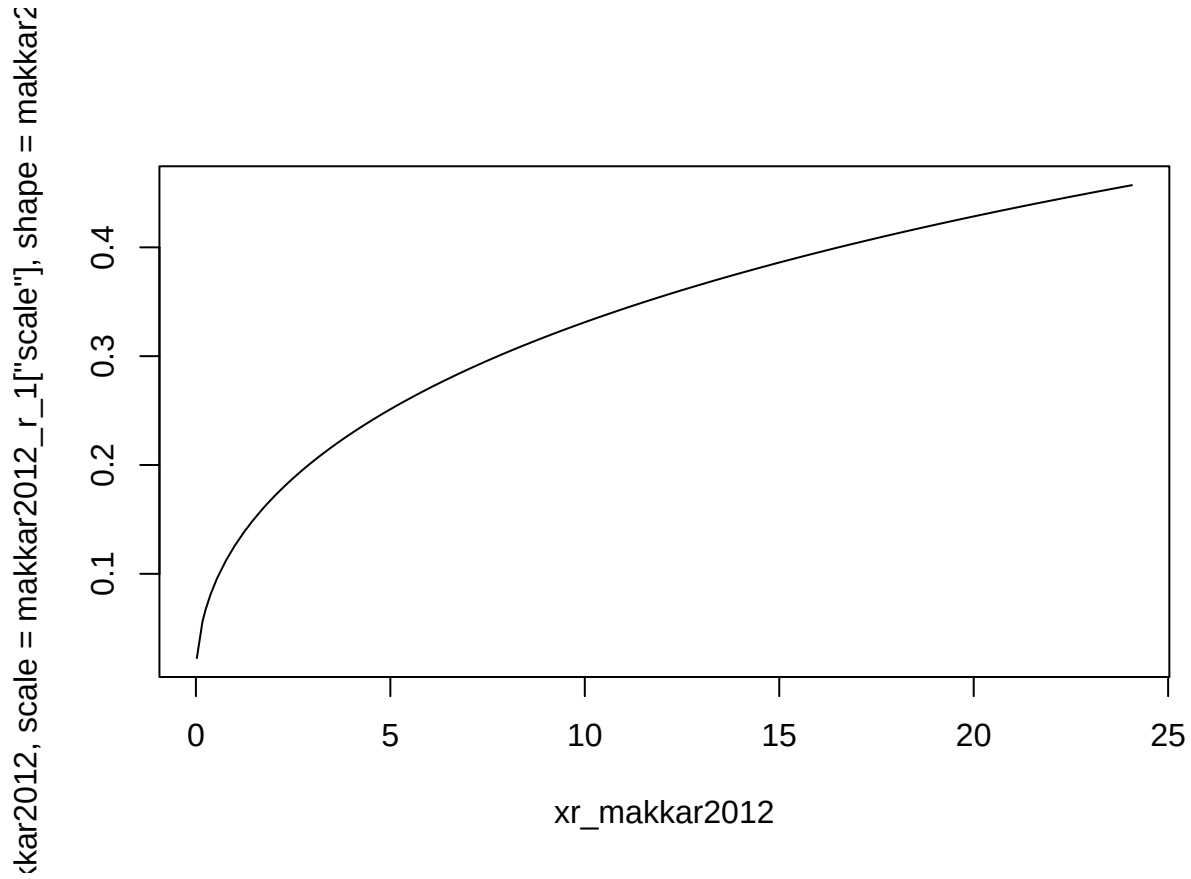


., 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

```
makkar2012_r_1
```

```
##     shape     scale
##  0.475537 67.866432
```

```
plot(xr_makkar2012,
     pweibull(xr_makkar2012,
              scale = makkar2012_r_1["scale"],
              shape = makkar2012_r_1["shape"]), type = "l")
```



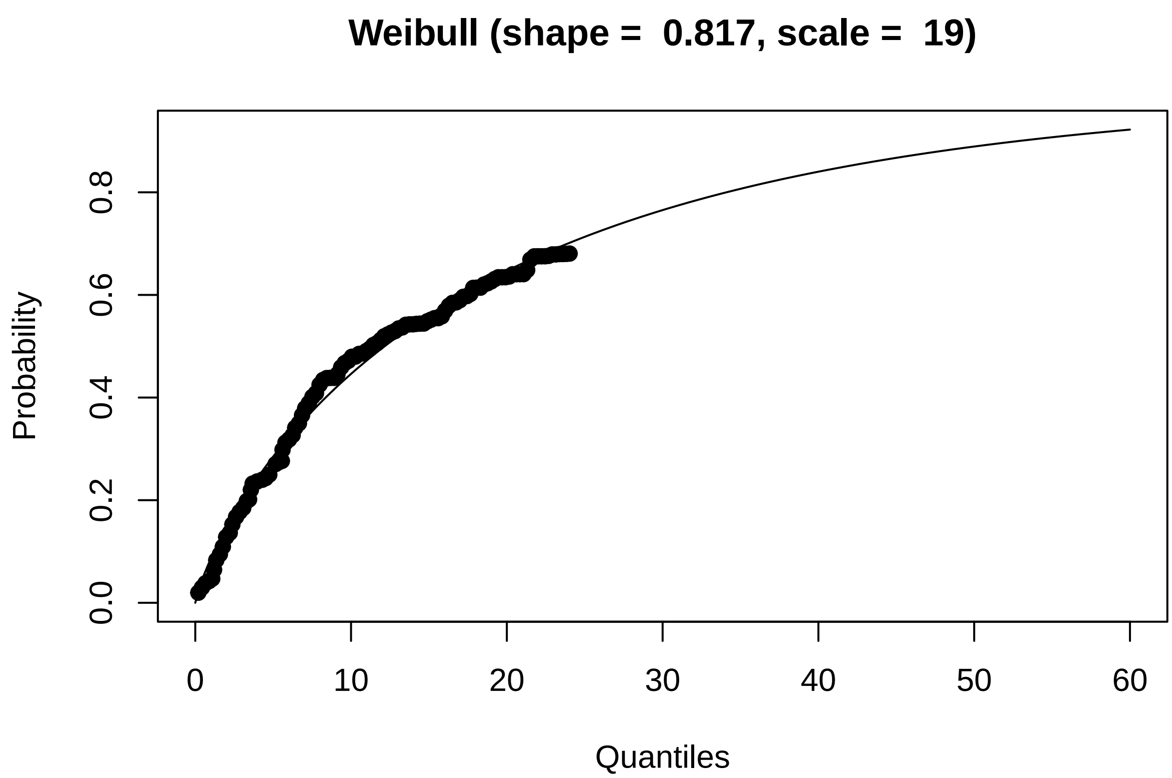

```
best_makkar2012_b_1 <- find_best_start_2parameter(p = yb_makkar2012/100, q = xb_makkar2012,
                                                  max_beta = 10, max_eta = 10,
                                                  steps_beta = 1, steps_eta = 1,
                                                  fitting_function = getweibullpar)
```

```
## Bester Startparameter: 0 6
## Bester Fehler: 3.115203e-06
```

```
makkar2012_b_1 <- getweibullpar(
                        p = yb_makkar2012/100,
                        q = xb_makkar2012,
                        start = best_makkar2012_b_1,
                        show.output = TRUE,
                        plot = TRUE
                      )
```

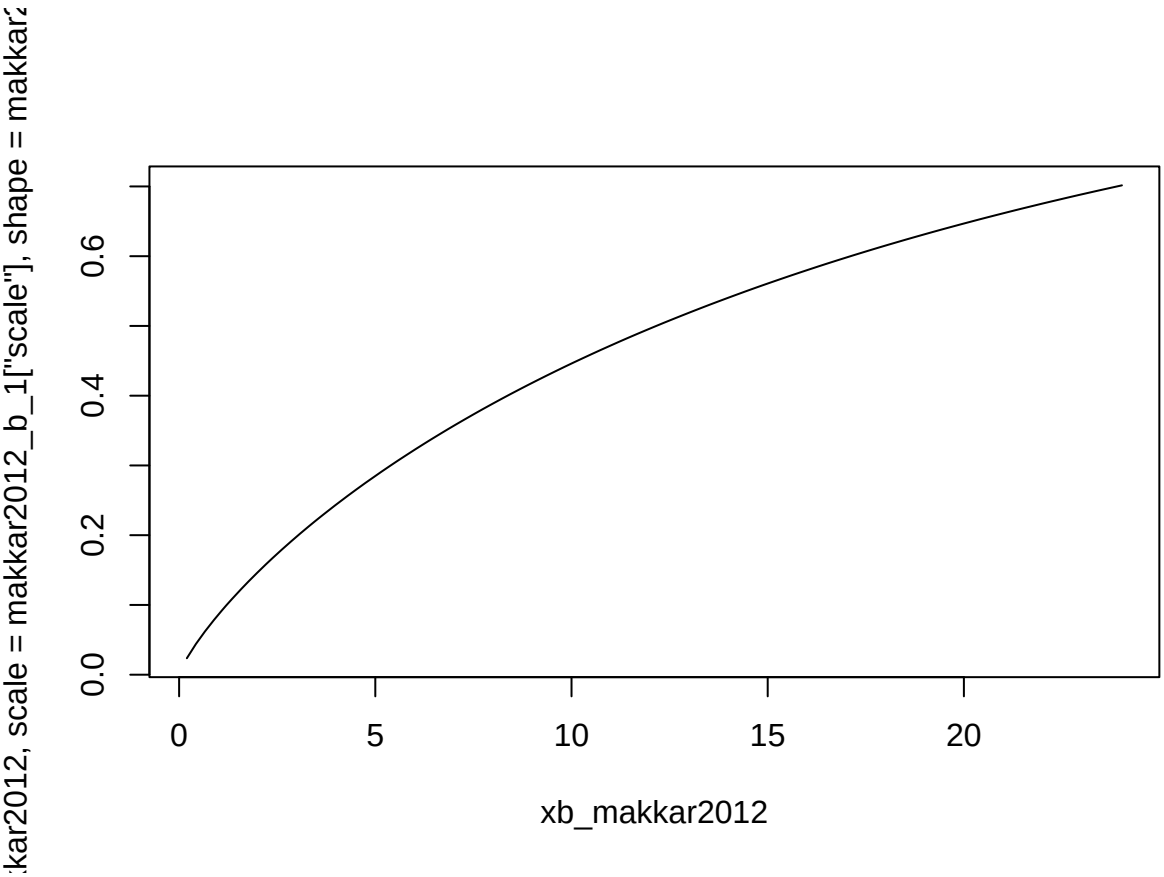
```
## $par
## [1]  0.8170087 19.0436324
```

```
##
## $value
## [1] 3.115203e-06
##
## $counts
## function gradient
##       21       21
##
## $convergence
## [1] 0
##
## $message
## [1] "CONVERGENCE: REL_REDUCTION_OF_F <= FACTR*EPSMCH"
```



., 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

```
plot(xb_makkar2012,
     pweibull(xb_makkar2012,
              scale = makkar2012_b_1["scale"],
              shape = makkar2012_b_1["shape"]), type = "l")
```



Exponentiierte Weibullverteilung

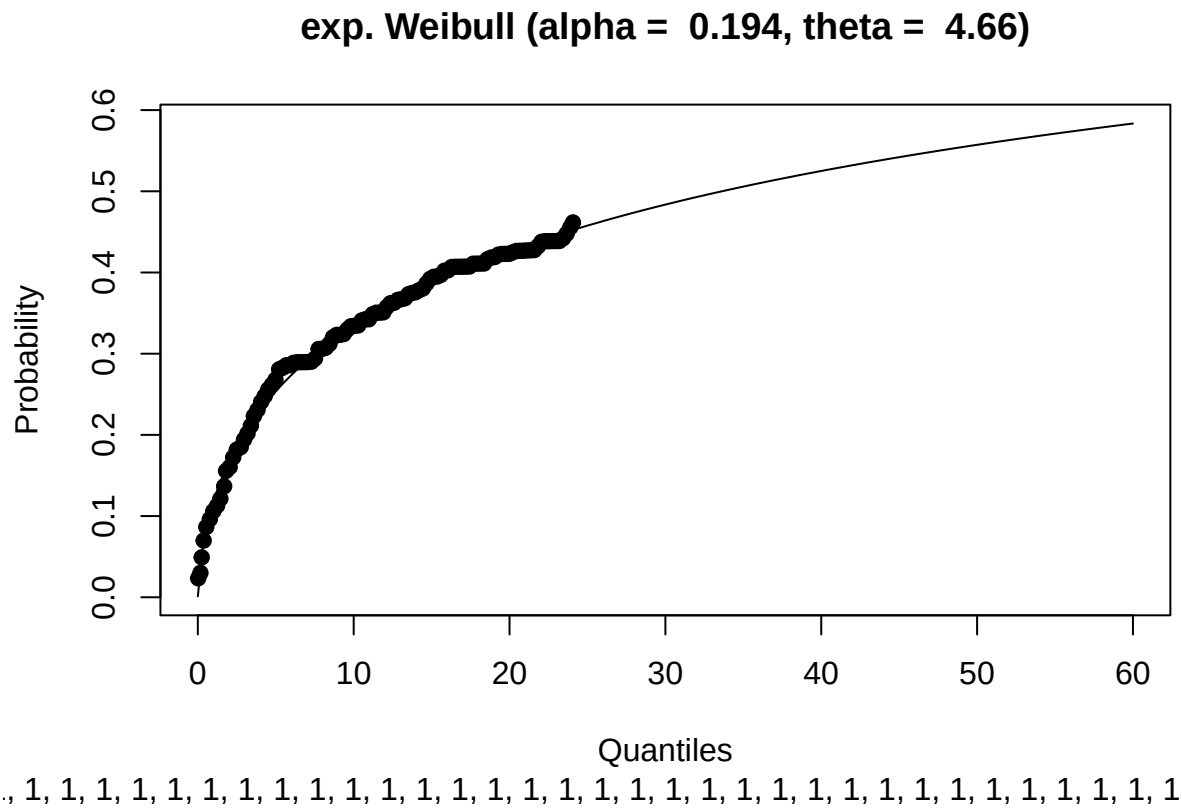
```
# exponentiierte Weibullverteilung
source("C:/Users/Chau/Documents/Masterarbeit/R Funktionen/getweibpar.R")

best_weibbull_xr_makkar2012 <- find_best_start_2parameter(p = yr_makkar2012/100,
                                                          q = xr_makkar2012,
                                                          max_beta = 10,
                                                          max_eta = 10,
                                                          steps_beta = 1,
                                                          steps_eta = 1,
                                                          fitting_function = getweibpar)
```

```
## Bester Startparameter: 0 8
## Bester Fehler: 4.866109e-07
```

```
weibbull_xr_makkar2012 <- getweibpar(
                          p = yr_makkar2012/100,
                          q = xr_makkar2012,
                          start = best_weibbull_xr_makkar2012,
                          show.output = TRUE,
                          plot = TRUE
                        )
```

```
## $par
## [1] 0.1943054 4.6643888
```

```
##
## $value
## [1] 4.866109e-07
##
## $counts
## function gradient
##       28       28
##
## $convergence
## [1] 0
##
## $message
## [1] "CONVERGENCE: REL_REDUCTION_OF_F <= FACTR*EPSMCH"
```

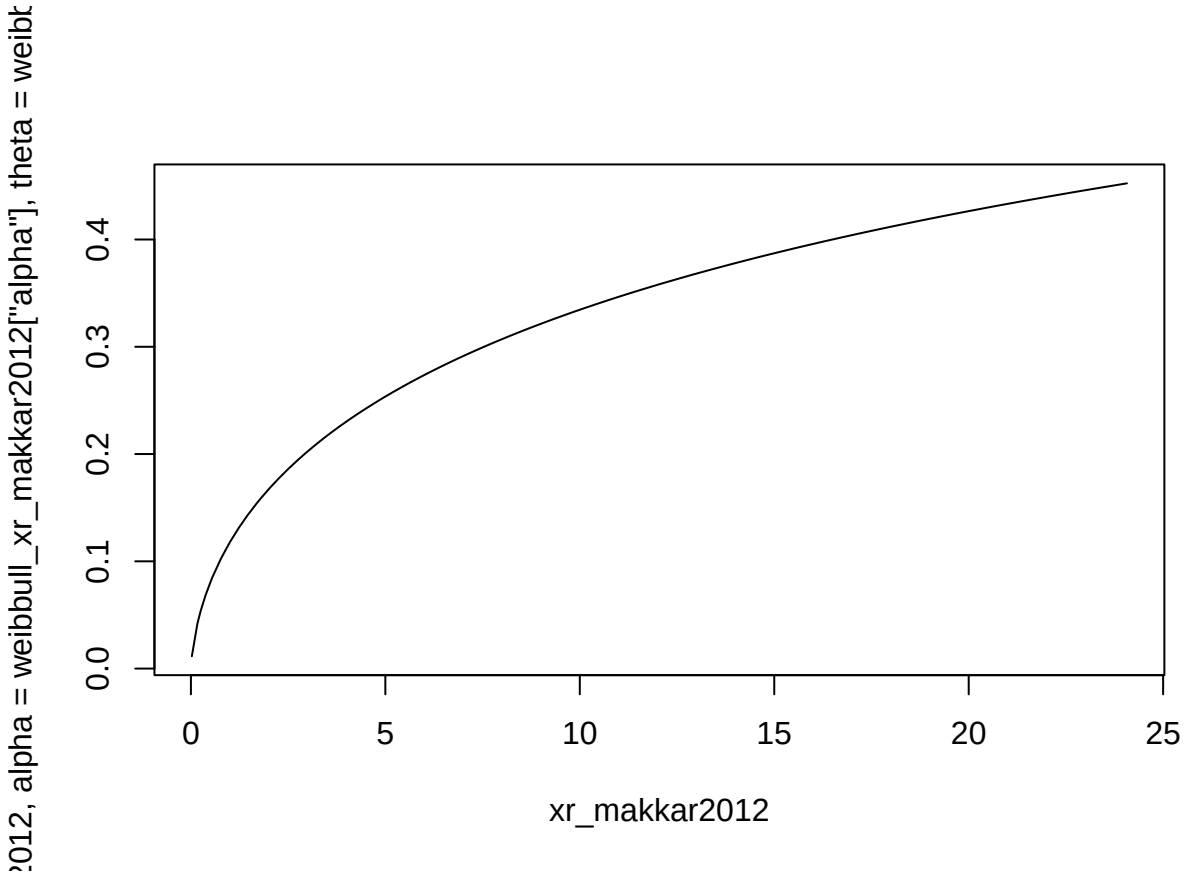


., 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

```
weibbull_xr_makkar2012
```

```
##     alpha     theta
## 0.1943054 4.6643888
```

```
plot(xr_makkar2012,
     pexpo.weibull(xr_makkar2012,
               alpha = weibbull_xr_makkar2012 ["alpha"],
               theta = weibbull_xr_makkar2012 ["theta"]), type = "l")
```



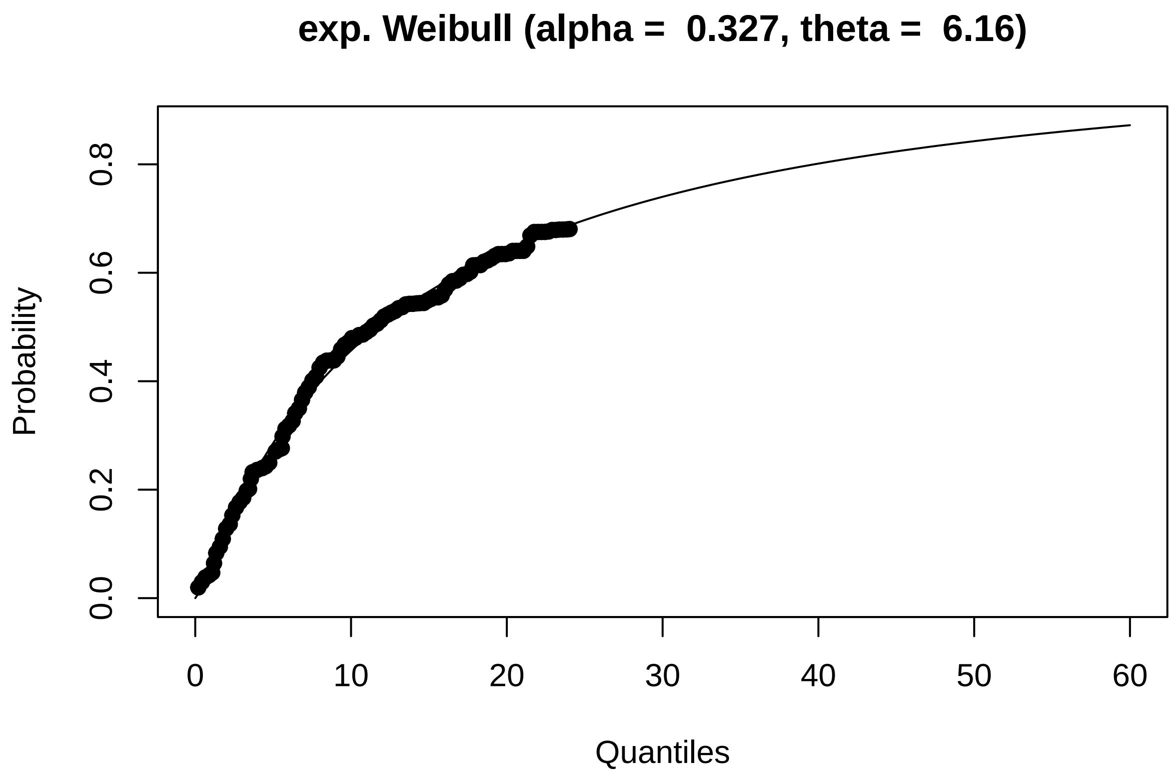

```
best_weibbull_xb_makkar2012 <- find_best_start_2parameter(p = yb_makkar2012/100,
                                                          q = xb_makkar2012,
                                                          max_beta = 10,
                                                          max_eta = 10,
                                                          steps_beta = 1,
                                                          steps_eta = 1,
                                                          fitting_function = getweibpar)
```

```
## Bester Startparameter: 0 0
## Bester Fehler: 1.390003e-06
```

```
weibbull_xb_makkar2012  <- getweibpar(
                          p = yb_makkar2012/100,
                          q = xb_makkar2012,
                          start = best_weibbull_xb_makkar2012,
                          show.output = TRUE,
                          plot = TRUE
                        )
```

```
## $par
## [1] 0.3272235 6.1608710
##
## $value
## [1] 1.390003e-06
##
## $counts
## function gradient
```

```
##       18       18
##
## $convergence
## [1] 0
##
## $message
## [1] "CONVERGENCE: REL_REDUCTION_OF_F <= FACTR*EPSMCH"
```

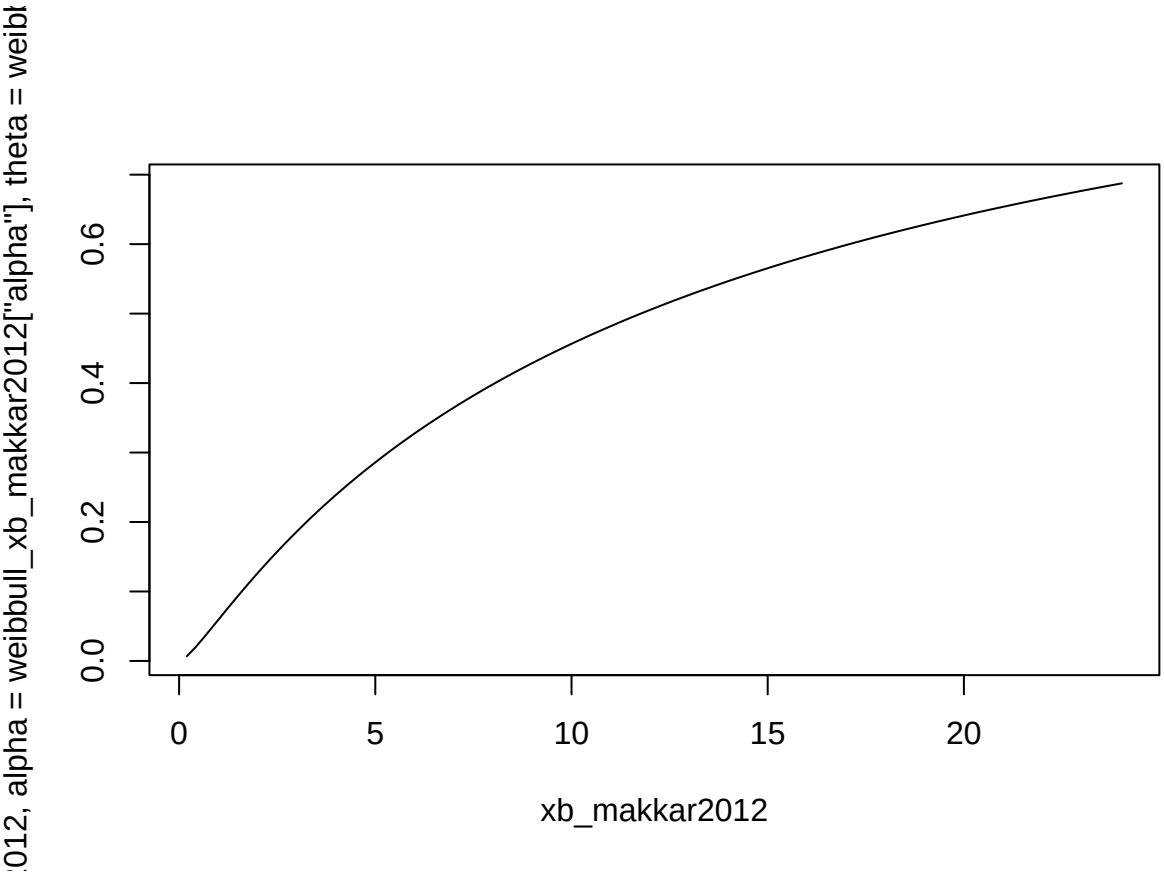


., 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

```
weibbull_xb_makkar2012
```

```
##     alpha     theta
## 0.3272235 6.1608710
```

```
plot(xb_makkar2012,
     pexpo.weibull(xb_makkar2012,
              alpha = weibbull_xb_makkar2012 ["alpha"],
              theta = weibbull_xb_makkar2012 ["theta"]), type = "l")
```



Mischung aus Weibull- und Exponentialverteilung

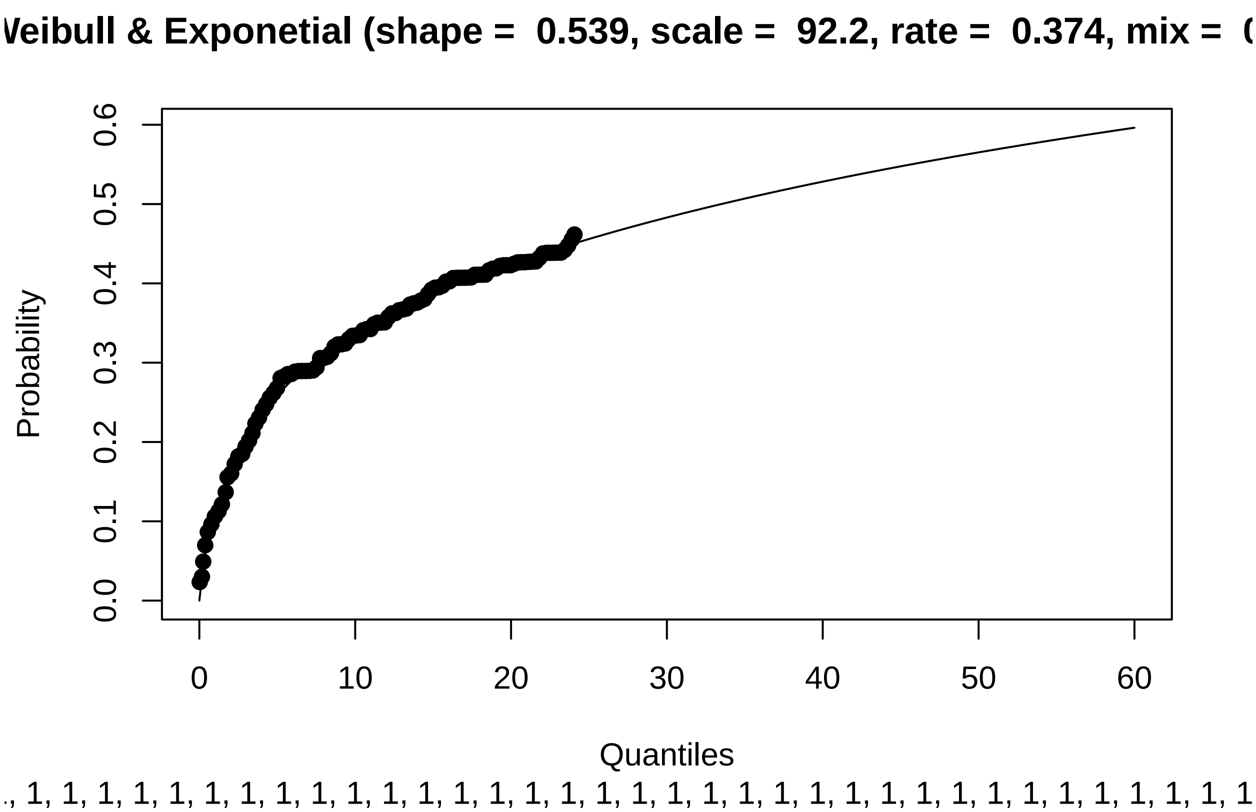
```
# Mischung aus Weibull- und Exponentialverteilung
source("C:/Users/Chau/Documents/Masterarbeit/R Funktionen/getweibex.R")

best_weibex_xr_makkar2012 <- find_best_start_4parameter(p = yr_makkar2012/100,
                                                        q = xr_makkar2012,
                                                        max_shape = 1,
                                                        max_scale = 100,
                                                        max_rate = 0.7,
                                                        max_mix = 1,
                                                        steps_shape = 0.1,
                                                        steps_scale = 20,
                                                        steps_rate = 0.1,
                                                        steps_mix = 0.1,
                                                        fitting_function = getweibex)
```

```
## Bester Startparameter: 0 0 0.5 0.9
## Bester Fehler: 3.464472e-07
```

```
weibex_xr_makkar2012 <- getweibex(
                        p = yr_makkar2012/100,
                        q = xr_makkar2012,
                        start = best_weibex_xr_makkar2012, # c(0.5, 60, 0.4, 0.1),
                        show.output = TRUE,
                        plot = TRUE
```

```
                        )
```

```
## $par
## [1]  0.5389911 92.2423487  0.3741991  2.1142420
##
## $value
## [1] 3.464472e-07
##
## $counts
## function gradient
##      124      124
##
## $convergence
## [1] 0
##
## $message
## [1] "CONVERGENCE: REL_REDUCTION_OF_F <= FACTR*EPSMCH"
```

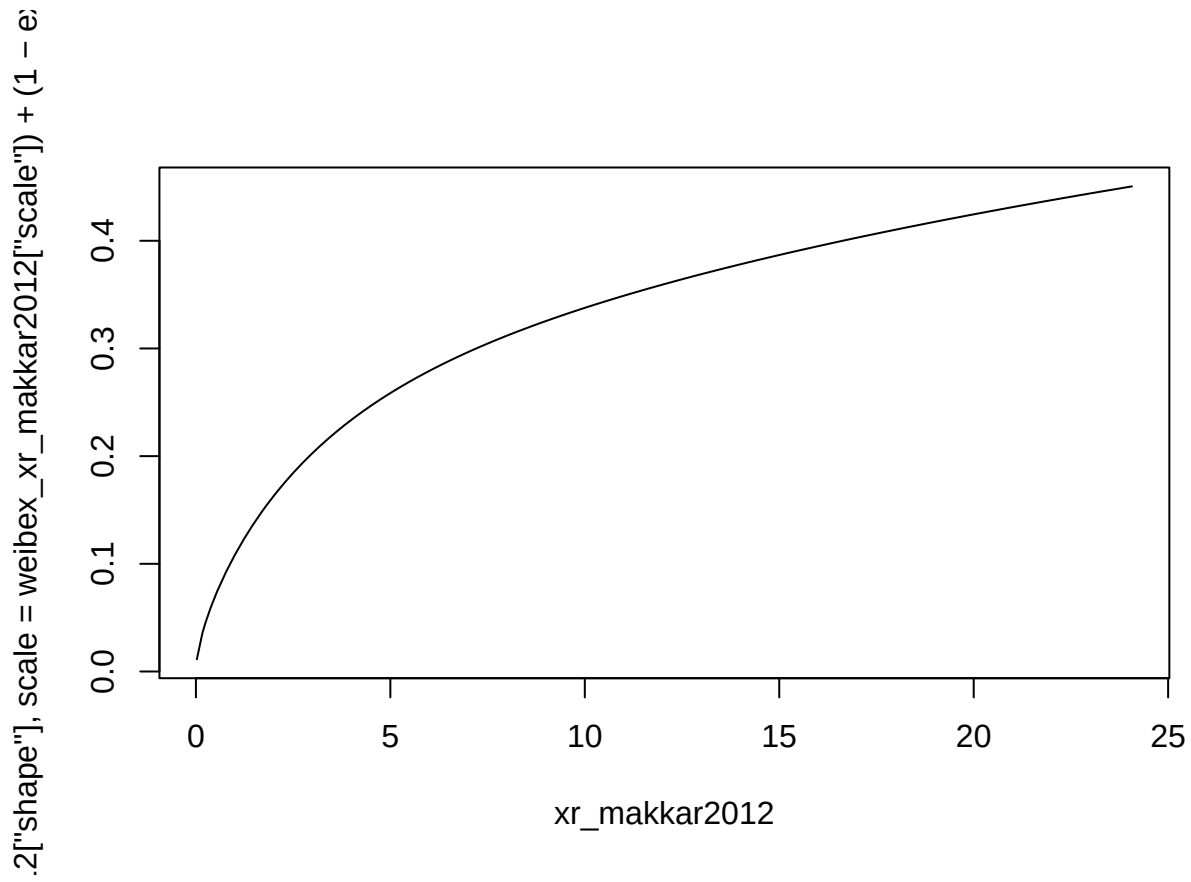



```
weibex_xr_makkar2012
```

```
##      shape      scale       rate        mix
##  0.5389911 92.2423487  0.3741991  2.1142420
```

```
# Wenn Ergebnisse aus weibex_xr1_1 von Funktion abgelesen
plot(xr_makkar2012,
     (exp(weibex_xr_makkar2012["mix"]) / ( 1 + exp(weibex_xr_makkar2012["mix"])) *
        stats::pweibull(q = xr_makkar2012,
```

```
                        shape = weibex_xr_makkar2012["shape"],
                        scale = weibex_xr_makkar2012["scale"]) +
       (1 - exp(weibex_xr_makkar2012["mix"]) / ( 1 + exp(weibex_xr_makkar2012["mix"]))) *
       stats::pexp(q = xr_makkar2012,
                   rate = weibex_xr_makkar2012["rate"])),
     type = "l")
```



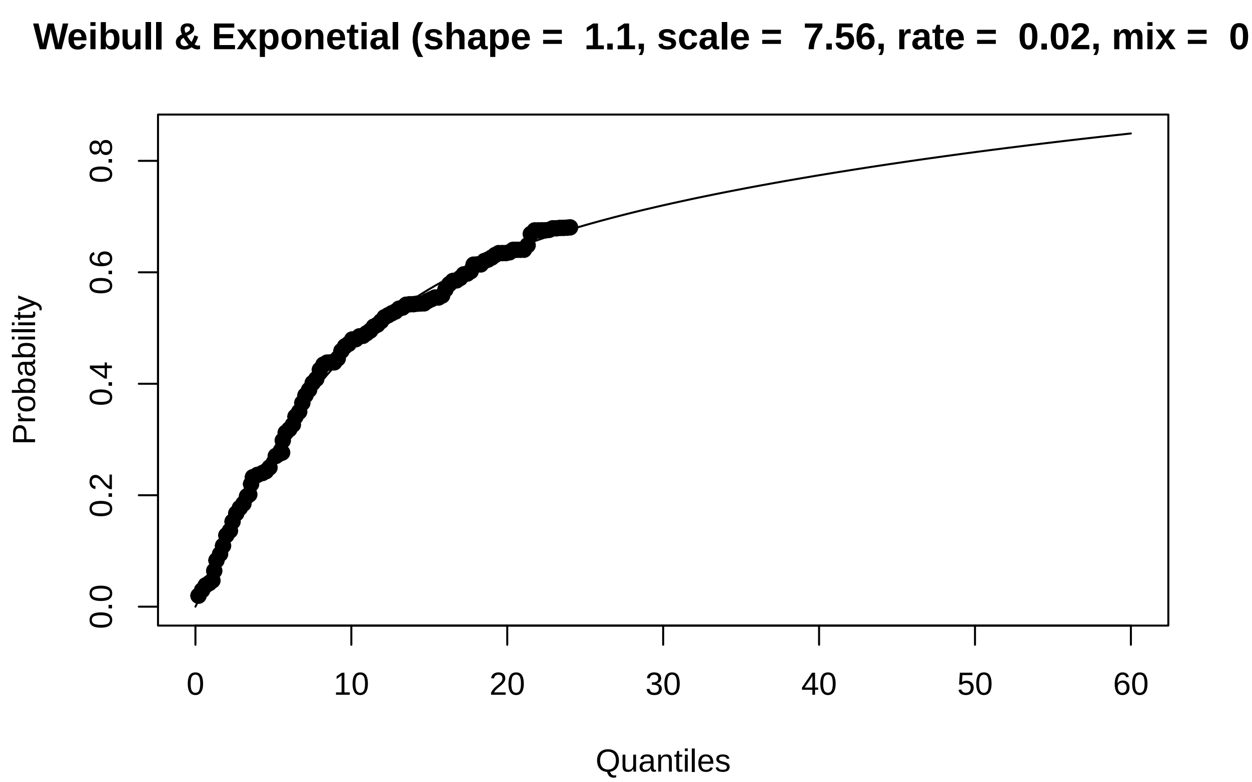

```
best_weibex_xb_makkar2012 <- find_best_start_4parameter(p = yb_makkar2012/100,
                                                        q = xb_makkar2012,
                                                        max_shape = 1,
                                                        max_scale = 100,
                                                        max_rate = 0.7,
                                                        max_mix = 1,
                                                        steps_shape = 0.1,
                                                        steps_scale = 20,
                                                        steps_rate = 0.1,
                                                        steps_mix = 0.1,
                                                        fitting_function = getweibex)
```

```
## Bester Startparameter: 0.3 0 0.7 0.8
## Bester Fehler: 1.268416e-06
```

```
weibex_xb_makkar2012 <- getweibex(
                        p = yb_makkar2012/100,
                        q = xb_makkar2012,
                        start = best_weibex_xb_makkar2012, # c(0.5, 60, 0.7, 0.1),
                        show.output = TRUE,
```

```
                        plot = TRUE
                      )
```

```
## $par
## [1] 1.10083120 7.56464412 0.01996295 0.00100000
##
## $value
## [1] 1.268416e-06
##
## $counts
## function gradient
##       48       48
##
## $convergence
## [1] 0
##
## $message
## [1] "CONVERGENCE: REL_REDUCTION_OF_F <= FACTR*EPSMCH"
```



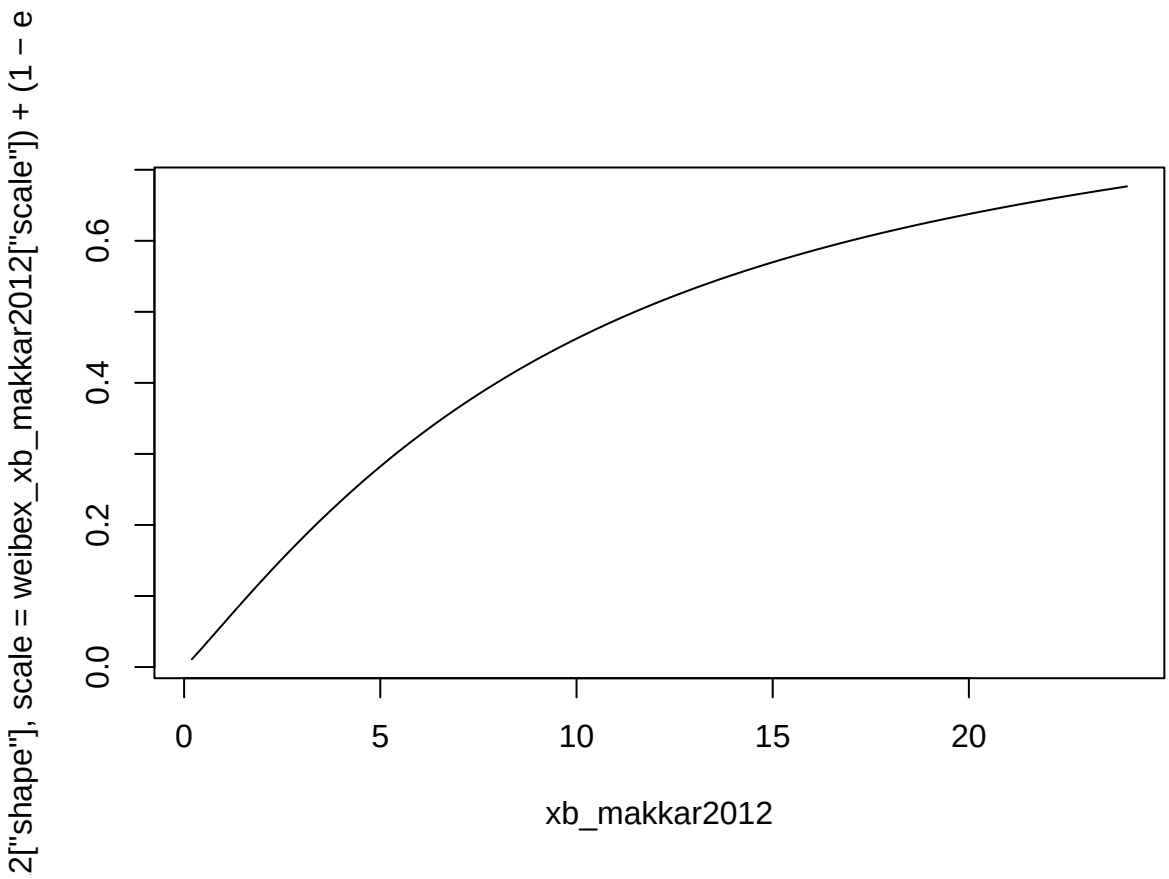
., 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

```
weibex_xb_makkar2012
```

```
##       shape       scale        rate         mix
## 1.10083120 7.56464412 0.01996295 0.00100000
```

```
plot(xb_makkar2012,
     (exp(weibex_xb_makkar2012["mix"]) / ( 1 + exp(weibex_xb_makkar2012["mix"])) *
        stats::pweibull(q = xb_makkar2012,
```

```
                        shape = weibex_xb_makkar2012["shape"],
                        scale = weibex_xb_makkar2012["scale"]) +
       (1 - exp(weibex_xb_makkar2012["mix"]) / ( 1 + exp(weibex_xb_makkar2012["mix"]))) *
       stats::pexp(q = xb_makkar2012,
                   rate = weibex_xb_makkar2012["rate"])),
     type = "l")
```



Mischung von exponentiierter Weibull- und Exponentialverteilung

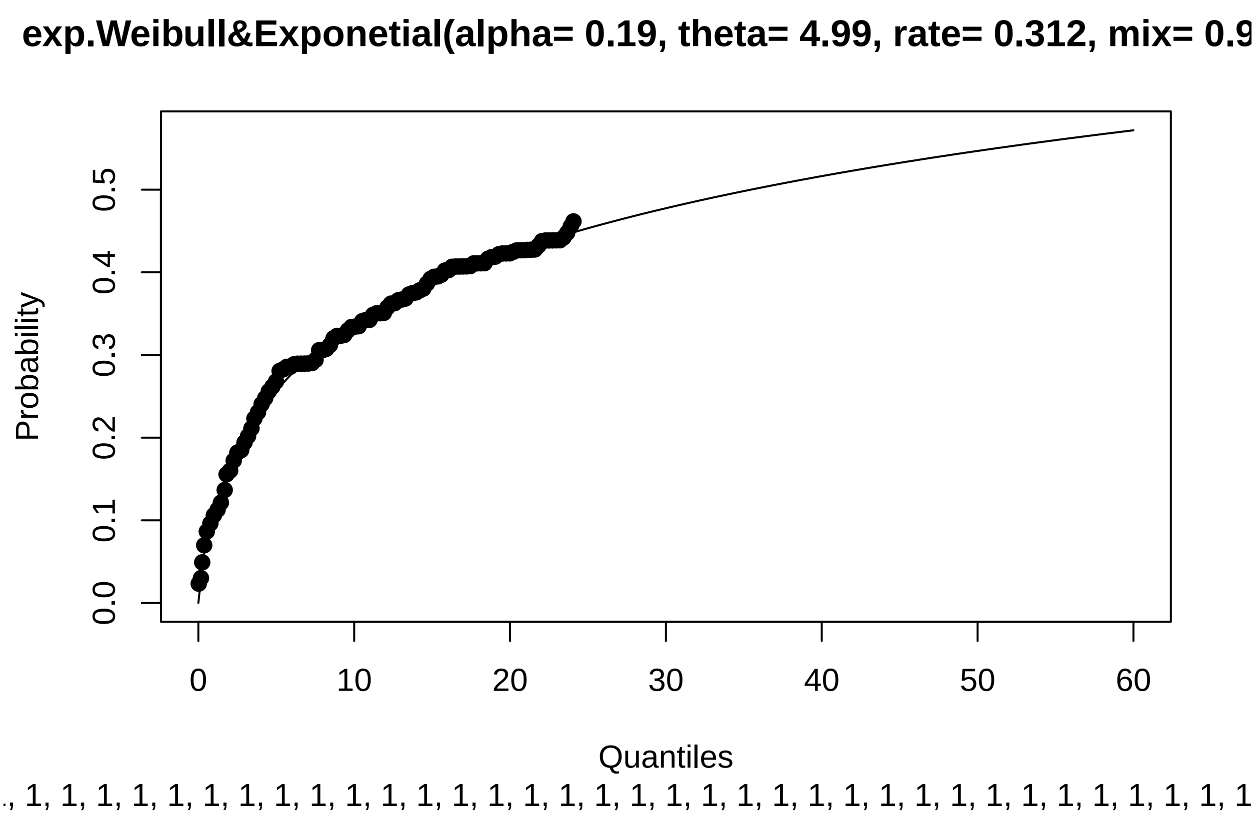
```
# Mischung von exponentiierter Weibull- und Exponentialverteilung
source("C:/Users/Chau/Documents/Masterarbeit/R Funktionen/get2weibex.R")

best_weibex2_xr_makkar2012 <- find_best_start_4parameter(p = yr_makkar2012/100,
                                                         q = xr_makkar2012,
                                                         max_shape = 1,
                                                         max_scale = 100,
                                                         max_rate = 0.7,
                                                         max_mix = 1,
                                                         steps_shape = 0.1,
                                                         steps_scale = 20,
                                                         steps_rate = 0.1,
                                                         steps_mix = 0.1,
                                                         fitting_function = get2weibex)
```

```
## Bester Startparameter: 0.1 0 0.4 0.8
```

```
## Bester Fehler: 3.748398e-07
```

```
weibex2_xr_makkar2012 <- get2weibex(
                          p = yr_makkar2012/100,
                          q = xr_makkar2012,
                          start = best_weibex2_xr_makkar2012,
                          show.output = TRUE,
                          plot = TRUE
                        )
```

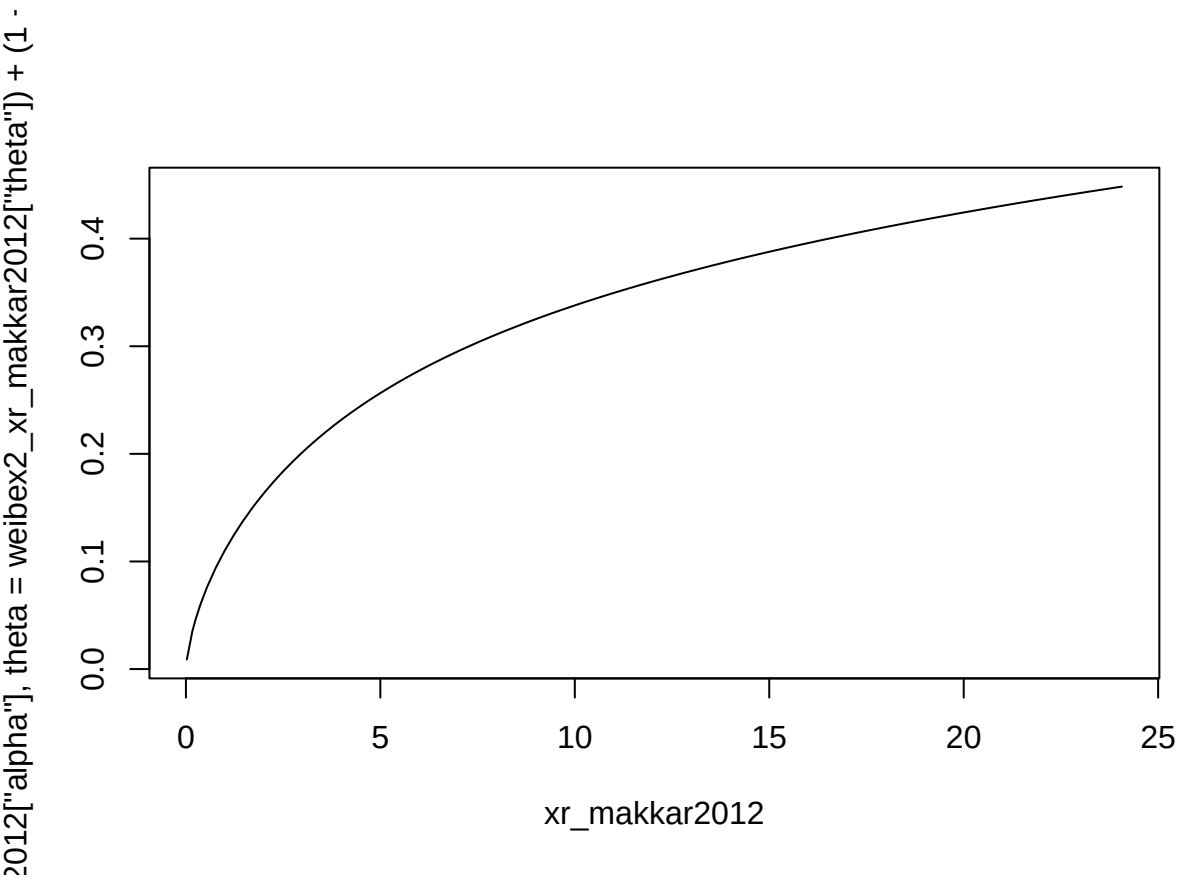
```
## $par
## [1] 0.1897616 4.9902927 0.3119952 2.8787582
##
## $value
## [1] 3.748398e-07
##
## $counts
## function gradient
##       70       70
##
## $convergence
## [1] 0
##
## $message
## [1] "CONVERGENCE: REL_REDUCTION_OF_F <= FACTR*EPSMCH"
```



```
weibex2_xr_makkar2012
```

```
##     alpha     theta      rate       mix
## 0.1897616 4.9902927 0.3119952 2.8787582
```

```
plot(xr_makkar2012,
     (exp(weibex2_xr_makkar2012["mix"]) / ( 1 + exp(weibex2_xr_makkar2012["mix"])) *
        reliaR::pexpo.weibull(q = xr_makkar2012,
                              alpha = weibex2_xr_makkar2012["alpha"],
                              theta = weibex2_xr_makkar2012["theta"]) +
        (1 - exp(weibex2_xr_makkar2012["mix"]) / ( 1 + exp(weibex2_xr_makkar2012["mix"]))) *
        stats::pexp(q = xr_makkar2012,
                    rate = weibex2_xr_makkar2012["rate"])),
     type = "l")
```

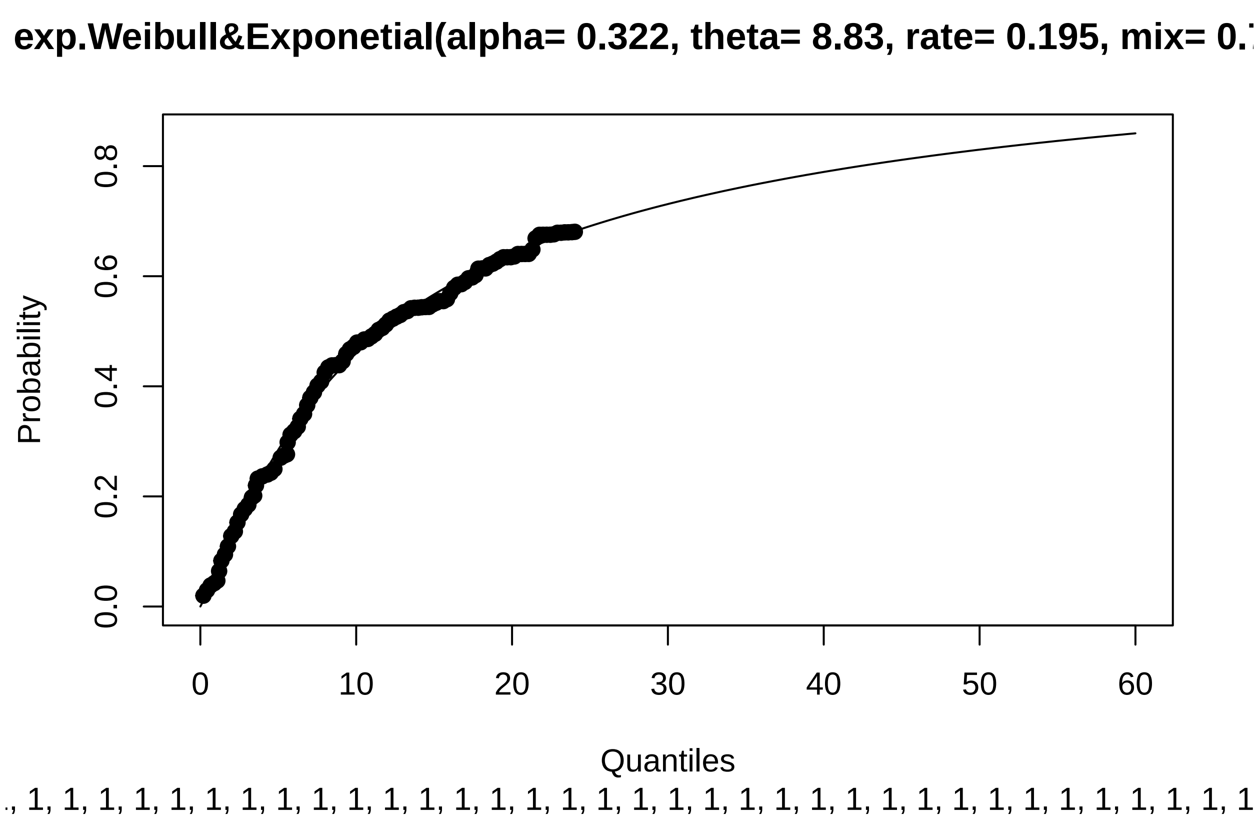



```
best_weibex2_xb_makkar2012 <- find_best_start_4parameter(p = yb_makkar2012/100,
                                                         q = xb_makkar2012,
                                                         max_shape = 1,
                                                         max_scale = 100,
                                                         max_rate = 0.7,
                                                         max_mix = 1,
                                                         steps_shape = 0.1,
                                                         steps_scale = 20,
                                                         steps_rate = 0.1,
                                                         steps_mix = 0.1,
                                                         fitting_function = get2weibex)
```

```
## Bester Startparameter: 0.1 0 0.7 0.7
## Bester Fehler: 1.221233e-06
```

```
weibex2_xb_makkar2012 <- get2weibex(
                         p = yb_makkar2012/100,
                         q = xb_makkar2012,
                         start = best_weibex2_xb_makkar2012,
                         show.output = TRUE,
                         plot = TRUE
                       )
```

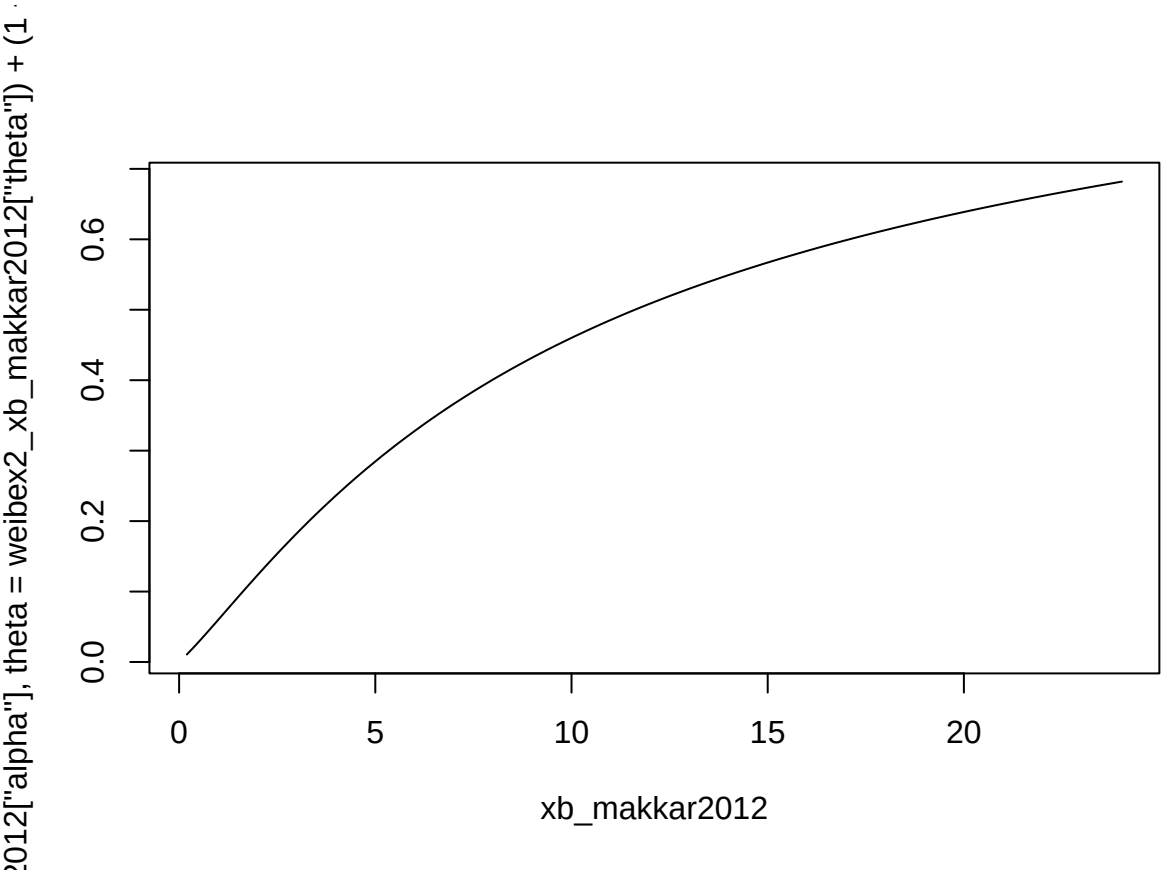
```
## $par
## [1] 0.3219864 8.8302090 0.1946066 1.0073081
##
## $value
## [1] 1.221233e-06
##
## $counts
## function gradient
##       42       42
##
## $convergence
## [1] 0
##
## $message
## [1] "CONVERGENCE: REL_REDUCTION_OF_F <= FACTR*EPSMCH"
```



```
weibex2_xb_makkar2012
```

```
##     alpha     theta      rate       mix
## 0.3219864 8.8302090 0.1946066 1.0073081
```

```
plot(xb_makkar2012,
     (exp(weibex2_xb_makkar2012["mix"]) / ( 1 + exp(weibex2_xb_makkar2012["mix"])) *
        reliaR::pexpo.weibull(q = xb_makkar2012,
                              alpha = weibex2_xb_makkar2012["alpha"],
                              theta = weibex2_xb_makkar2012["theta"]) +
        (1 - exp(weibex2_xb_makkar2012["mix"]) / ( 1 + exp(weibex2_xb_makkar2012["mix"]))) *
        stats::pexp(q = xb_makkar2012,
                    rate = weibex2_xb_makkar2012["rate"])),
     type = "l")
```



Exponentiierte Weibullverteilung ohne Lambda = 1

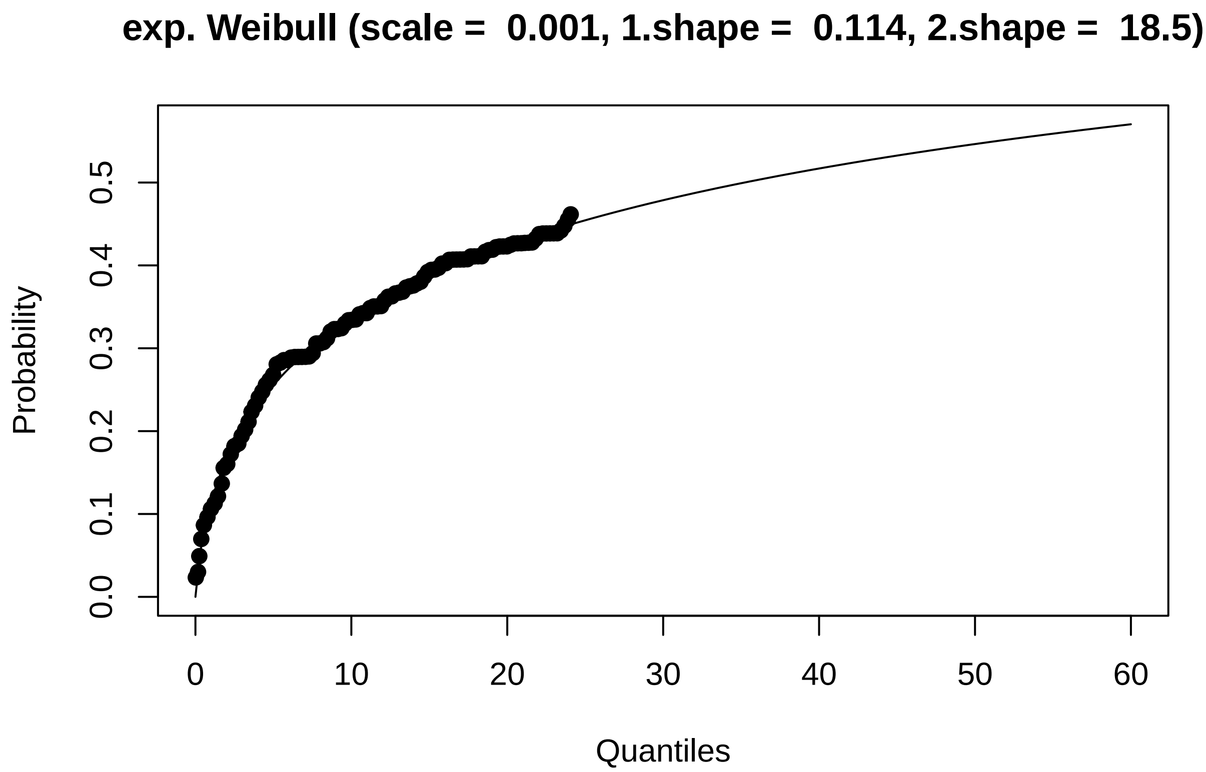
```
# exponentiierte Weibullverteilung ohne Lambda = 1
source("C:/Users/Chau/Documents/Masterarbeit/R Funktionen/getexpweib.R")

best_expweib_xr_makkar2012 <- find_best_start_3parameter(p = yr_makkar2012/100,
                                                         q = xr_makkar2012,
                                                         max_shape1 = 10,
                                                         max_shape2 = 10,
                                                         max_scale = 10,
                                                         steps_shape1 = 1,
```

```
                                                    steps_shape2 = 1,
                                                    steps_scale = 1,
                                                    fitting_function = getexpweib)
```

```
## Bester Startparameter: 4 3 9
## Bester Fehler: 4.159876e-07
```

```
expweib_xr_makkar2012 <- getexpweib(
                          p = yr_makkar2012/100,
                          q = xr_makkar2012,
                          start = best_expweib_xr_makkar2012,
                          show.output = TRUE,
                          plot = TRUE
                        )
```

```
## $par
## [1]  0.0010000  0.1140994 18.4820182
##
## $value
## [1] 4.159876e-07
##
## $counts
## function gradient
##       46       46
##
## $convergence
## [1] 0
##
## $message
## [1] "CONVERGENCE: REL_REDUCTION_OF_F <= FACTR*EPSMCH"
```

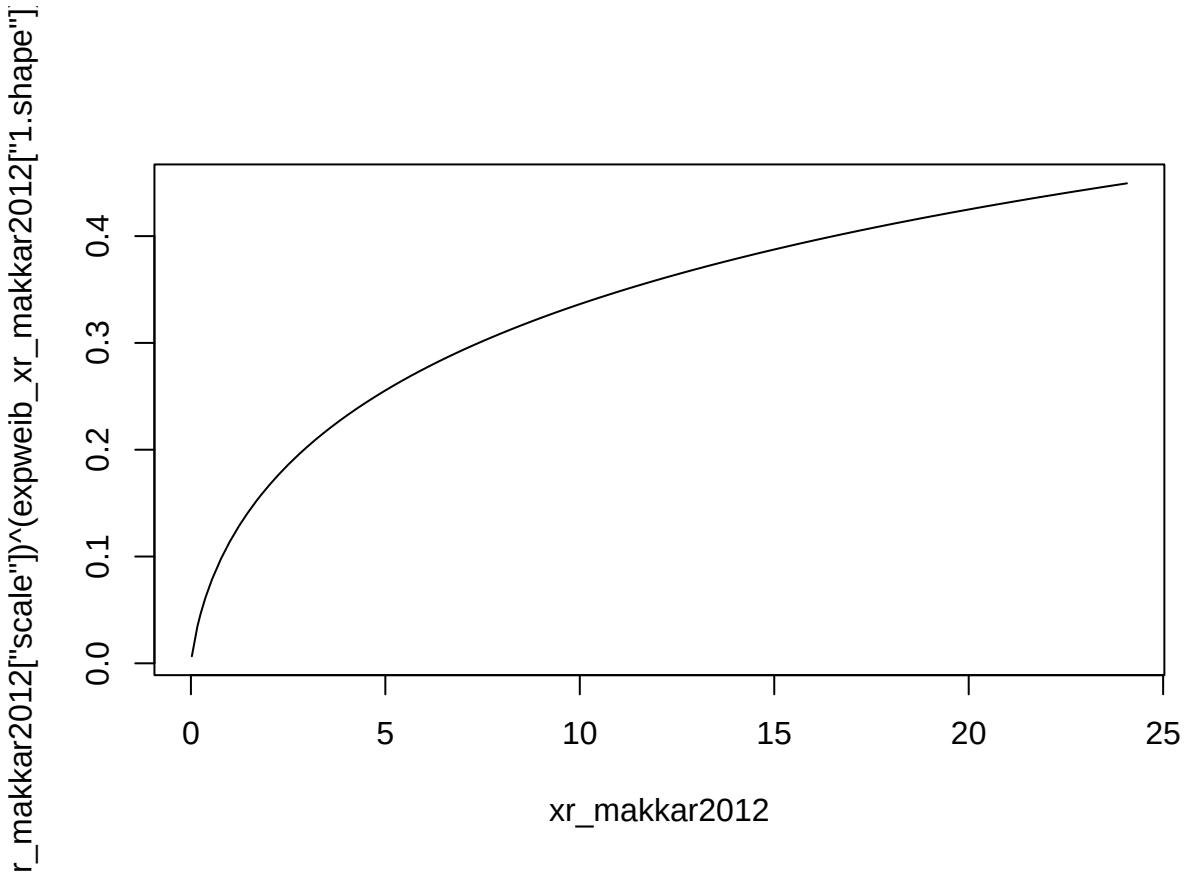


., 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

```
expweib_xr_makkar2012
```

```
##       scale     1.shape     2.shape
##   0.0010000   0.1140994 18.4820182
```

```
plot(xr_makkar2012,
     (1 - exp(-(xr_makkar2012 / expweib_xr_makkar2012["scale"])^
                      (expweib_xr_makkar2012["1.shape"]))) ^ (expweib_xr_makkar2012["2.shape"]),
     type = "l")
```



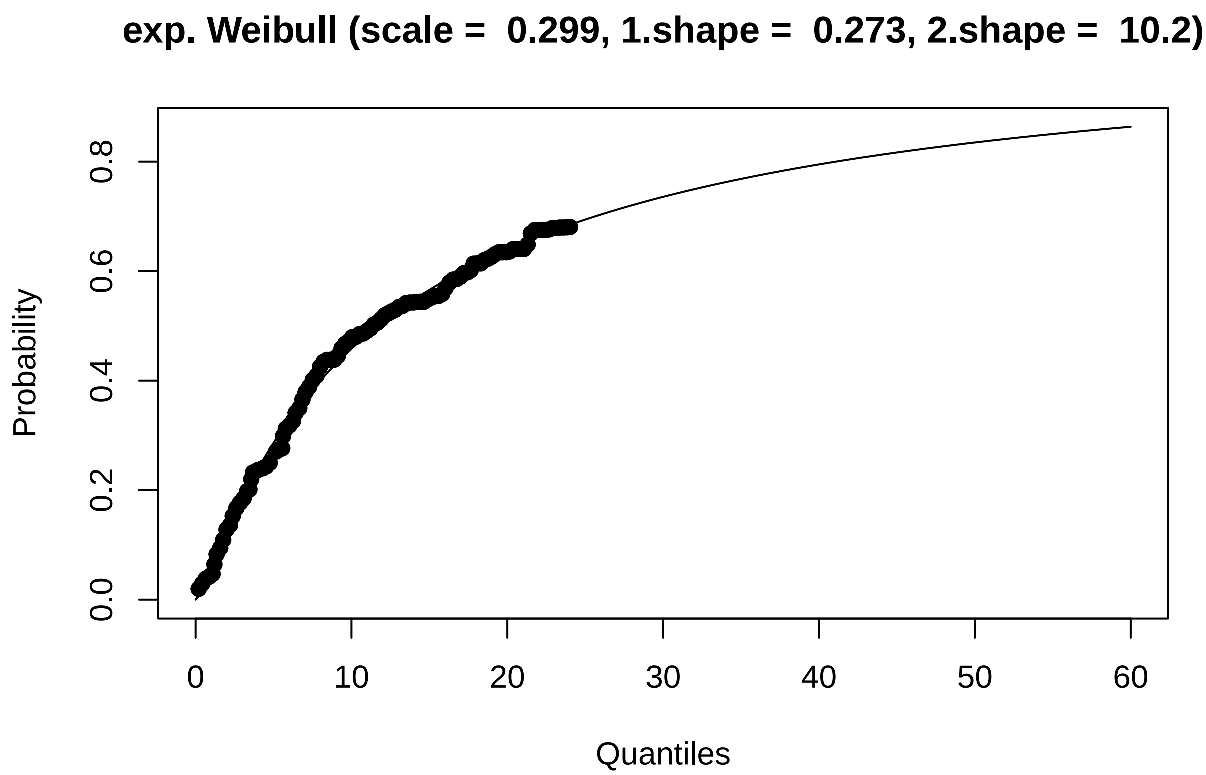

```
best_expweib_xb_makkar2012 <- find_best_start_3parameter(p = yb_makkar2012/100,
                                                         q = xb_makkar2012,
                                                         max_shape1 = 10,
                                                         max_shape2 = 10,
                                                         max_scale = 10,
                                                         steps_shape1 = 1,
                                                         steps_shape2 = 1,
                                                         steps_scale = 1,
                                                         fitting_function = getexpweib)
```

```
## Bester Startparameter: 2 3 10
## Bester Fehler: 1.30067e-06
```

```
expweib_xb_makkar2012 <- getexpweib(
                          p = yb_makkar2012/100,
                          q = xb_makkar2012,
                          start = best_expweib_xb_makkar2012,
                          show.output = TRUE,
                          plot = TRUE
                        )
```

```
## $par
## [1]  0.2994815  0.2728216 10.1569640
##
## $value
## [1] 1.30067e-06
##
```

```
## $counts
## function gradient
##       34       34
##
## $convergence
## [1] 0
##
## $message
## [1] "CONVERGENCE: REL_REDUCTION_OF_F <= FACTR*EPSMCH"
```

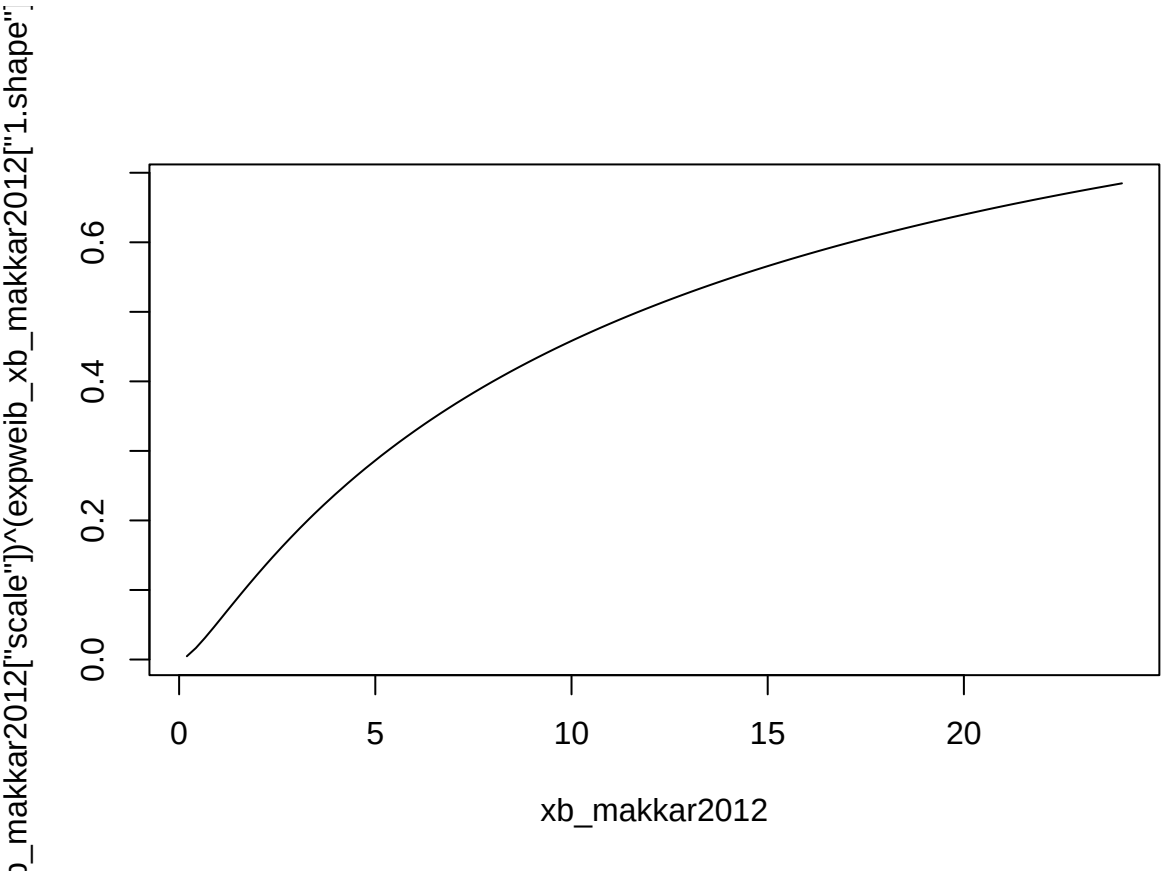


., 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

```r
expweib_xb_makkar2012
```

```
##      scale    1.shape    2.shape
##  0.2994815  0.2728216 10.1569640
```

```r
plot(xb_makkar2012,
     (1 - exp(-(xb_makkar2012 / expweib_xb_makkar2012["scale"])^(expweib_xb_makkar2012["1.shape"])))^(e
     type = "l")
```



3-Stufige Exponetialverteilung

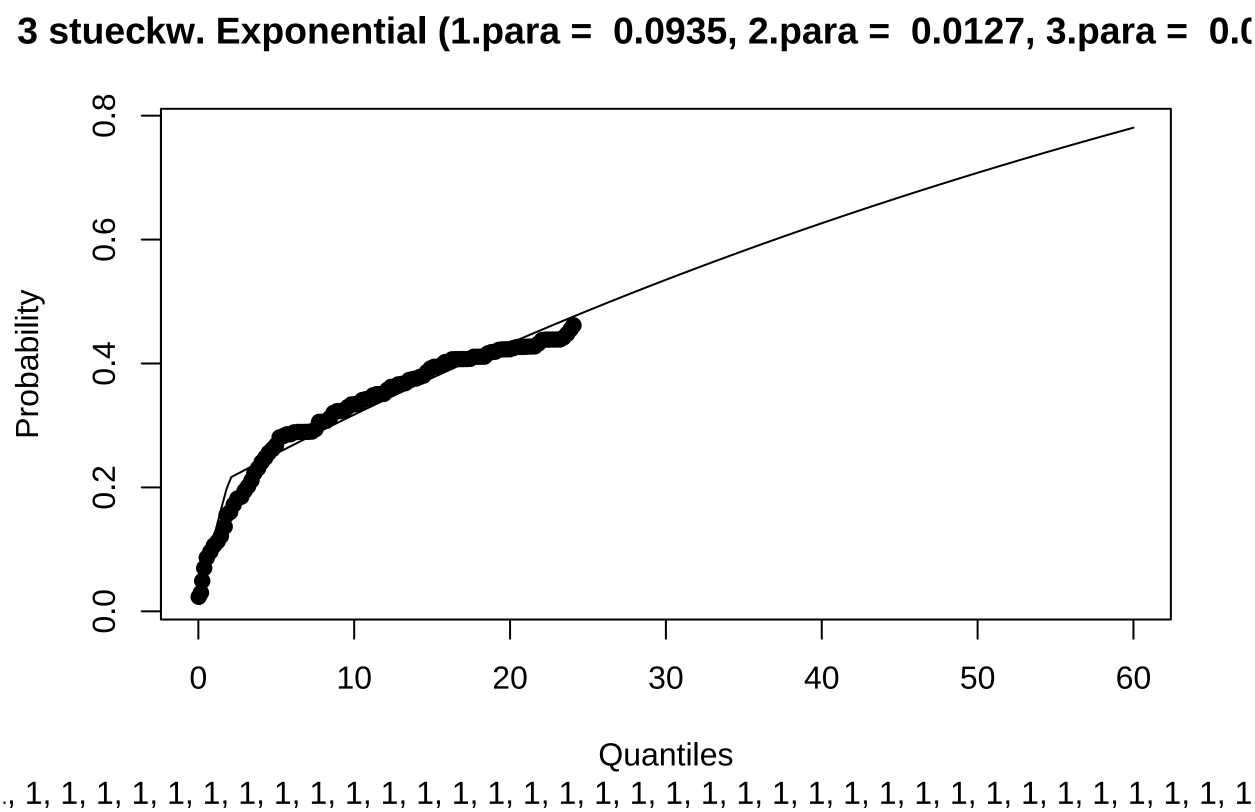
```
# 3-Stufige Exponetialverteilung
source("C:/Users/Chau/Documents/Masterarbeit/R Funktionen/getstuexp3.R")

best_stuexp3_xr_makkar2012 <- find_best_start_3parameter(p = yr_makkar2012/100,
                                                         q = xr_makkar2012,
                                                         max_shape1 = 0.1,
                                                         max_shape2 = 0.1,
                                                         max_scale = 0.1,
                                                         steps_shape1 = 0.01,
                                                         steps_shape2 = 0.01,
                                                         steps_scale = 0.01,
                                                         fitting_function = getstuexp3)
```

```
## Bester Startparameter: 0.04 0 0.1
## Bester Fehler: 3.268365e-06
```

```
stuexp3_xr_makkar2012 <- getstuexp3(
                          p = yr_makkar2012/100,
                          q = xr_makkar2012,
                          start = best_stuexp3_xr_makkar2012,
                          show.output = TRUE,
                          plot = TRUE,
                          wert1 = 2,
                          wert2 = 6
```

```r
                      )
```

```
## $par
## [1] 0.09351611 0.01274085 0.00100000
##
## $value
## [1] 3.268365e-06
##
## $counts
## function gradient
##       29       29
##
## $convergence
## [1] 0
##
## $message
## [1] "CONVERGENCE: REL_REDUCTION_OF_F <= FACTR*EPSMCH"
```

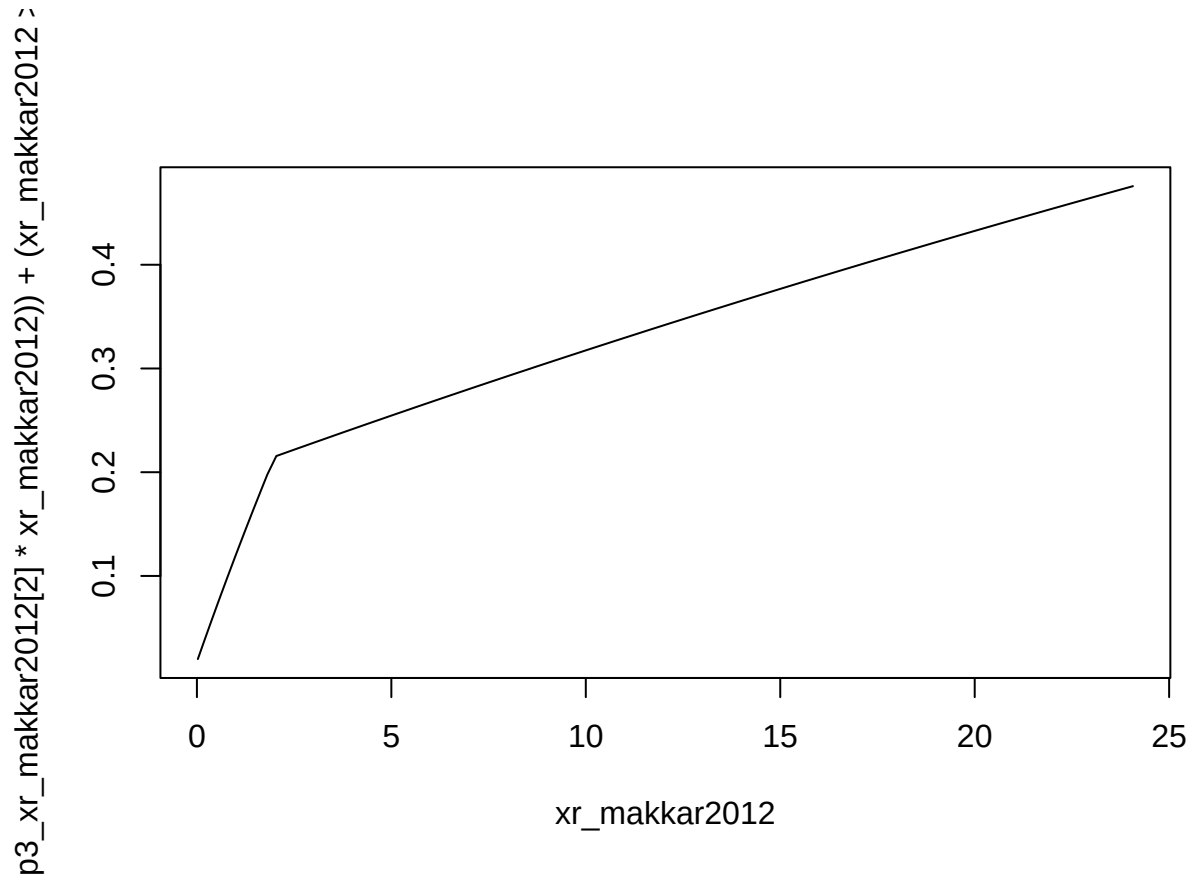



```r
stuexp3_xr_makkar2012
```

```
##      1.para     2.para     3.para
## 0.09351611 0.01274085 0.00100000
```

```r
plot(xr_makkar2012,
     ((xr_makkar2012 > 0 & xr_makkar2012 <= 2 ) * (1 - exp(-stuexp3_xr_makkar2012[1] * xr_makkar2012)) +
                                (xr_makkar2012 > 2 & xr_makkar2012 <= 6 ) *
              (1 - exp(-stuexp3_xr_makkar2012[1] * 2))  +
```

```
                                    (exp(-2 * stuexp3_xr_makkar2012[2]) -
                                            exp(-stuexp3_xr_makkar2012[2] * xr_makkar2012)) +
                                    (xr_makkar2012 > 6 & xr_makkar2012 <= 65 ) *
            (1 - exp(-stuexp3_xr_makkar2012[1] * 2)) +
                                    (exp(-2 * stuexp3_xr_makkar2012[2]) - exp(-6 * stuexp3_xr_makkar2012
                                    (exp(-6 * stuexp3_xr_makkar2012[3]) -
                                            exp(-stuexp3_xr_makkar2012[3] * xr_makkar2012))),
    type = "l")
```



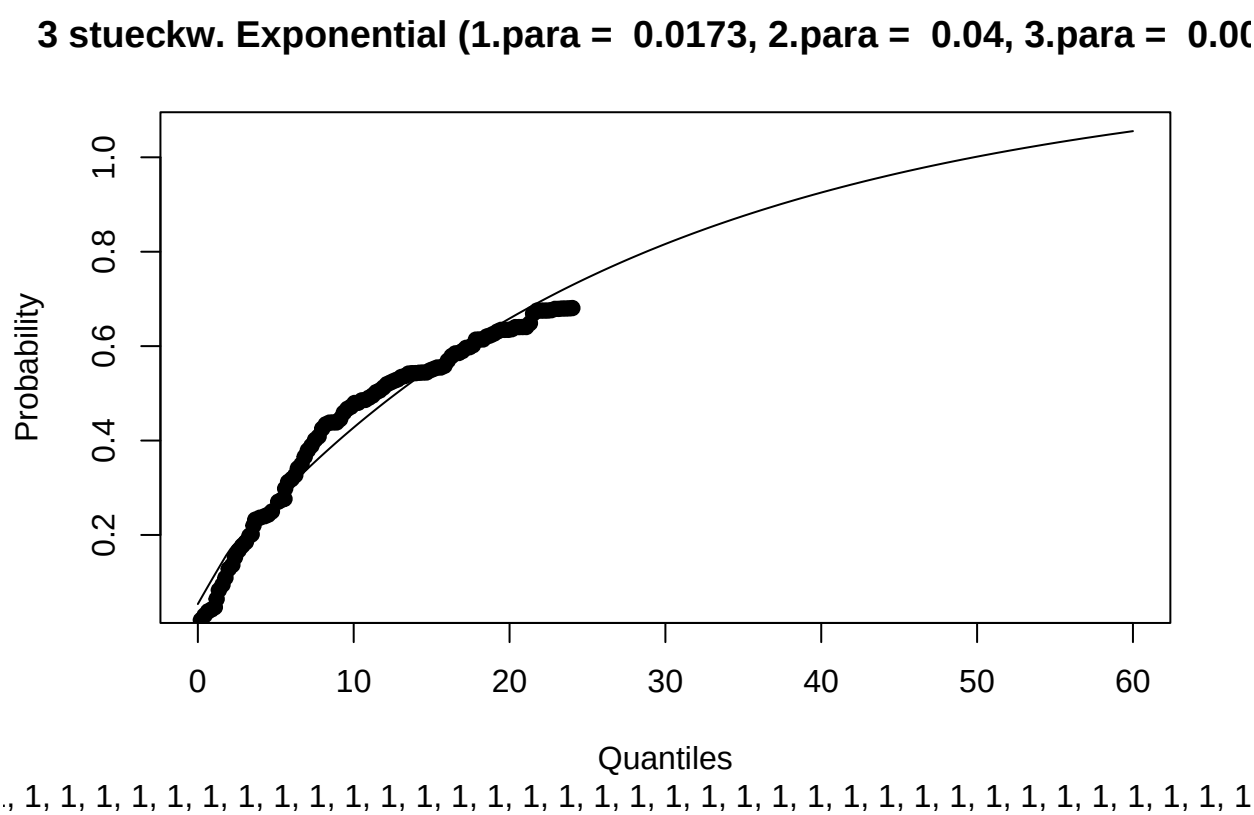

```
best_stuexp3_xb_makkar2012 <- find_best_start_3parameter(p = yb_makkar2012/100,
                                                         q = xb_makkar2012,
                                                         max_shape1 = 0.1,
                                                         max_shape2 = 0.1,
                                                         max_scale = 0.1,
                                                         steps_shape1 = 0.01,
                                                         steps_shape2 = 0.01,
                                                         steps_scale = 0.01,
                                                         fitting_function = getstuexp3)
```

```
## Bester Startparameter: 0.07 0.02 0
## Bester Fehler: 9.227159e-06
```

```
stuexp3_xb_makkar2012 <- getstuexp3(
                         p = yb_makkar2012/100,
                         q = xb_makkar2012,
                         start = best_stuexp3_xb_makkar2012,
                         show.output = TRUE,
```

```
                        plot = TRUE,
                        wert1 = 2,
                        wert2 = 6
                      )
```

```
## $par
## [1] 0.01730589 0.04003948 0.00100000
##
## $value
## [1] 9.227159e-06
##
## $counts
## function gradient
##       25       25
##
## $convergence
## [1] 0
##
## $message
## [1] "CONVERGENCE: REL_REDUCTION_OF_F <= FACTR*EPSMCH"
```

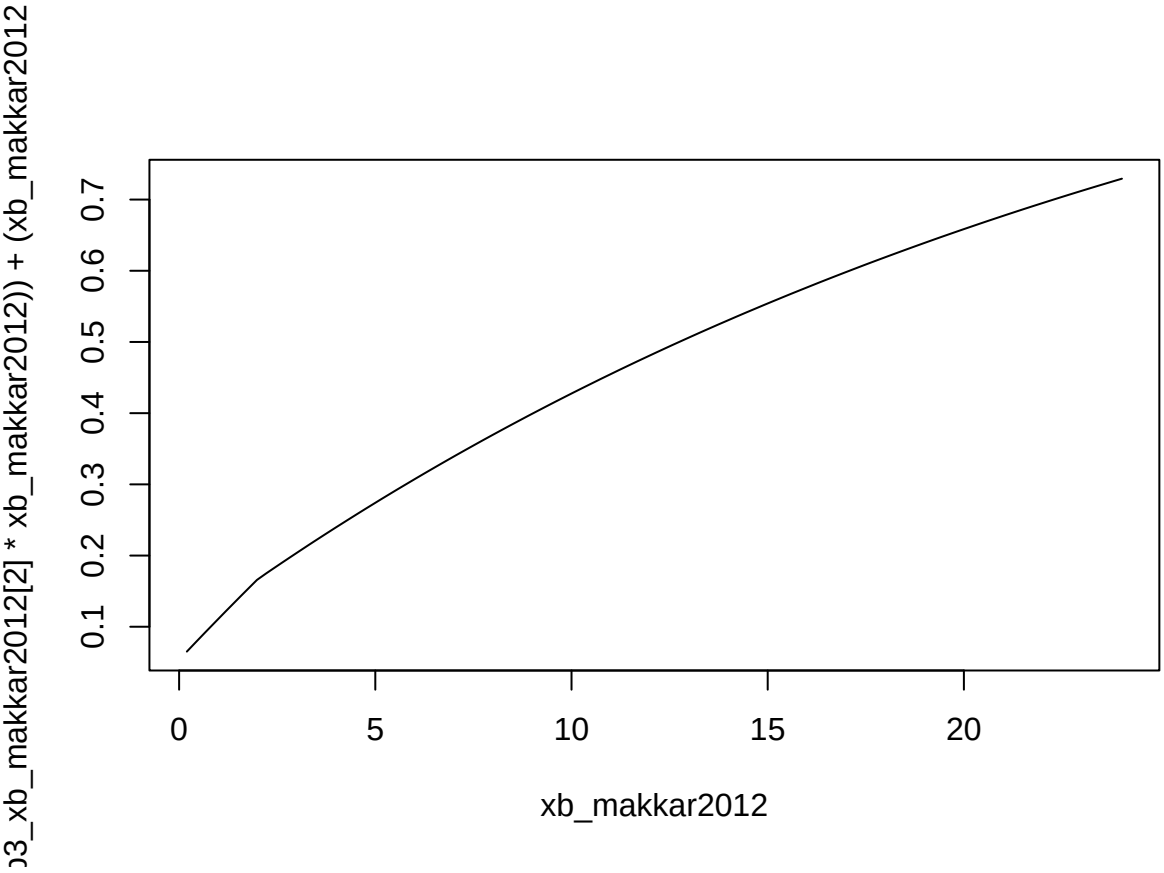


., 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

```
stuexp3_xb_makkar2012
```

```
##     1.para     2.para     3.para
## 0.01730589 0.04003948 0.00100000
```

```r
plot(xb_makkar2012,
     ((xb_makkar2012 > 0 & xb_makkar2012 <= 2 ) * (1 - exp(-stuexp3_xb_makkar2012[1] * xb_makkar2012)) +
                                  (xb_makkar2012 > 2 & xb_makkar2012 <= 6 ) *
              (1 - exp(-stuexp3_xb_makkar2012[1] * 2))  +
                                  (exp(-2 * stuexp3_xb_makkar2012[2]) - exp(-stuexp3_xb_makkar2012[2] *
                                                                              xb_makkar2012)) +
                                  (xb_makkar2012 > 6 & xb_makkar2012 <= 65 ) *
              (1 - exp(-stuexp3_xb_makkar2012[1] * 2)) +
                                  (exp(-2 * stuexp3_xb_makkar2012[2]) - exp(-6 * stuexp3_xb_makkar2012
                                  (exp(-6 * stuexp3_xb_makkar2012[3]) -
                                           exp(-stuexp3_xb_makkar2012[3] * xb_makkar2012))),
     type = "l")
```



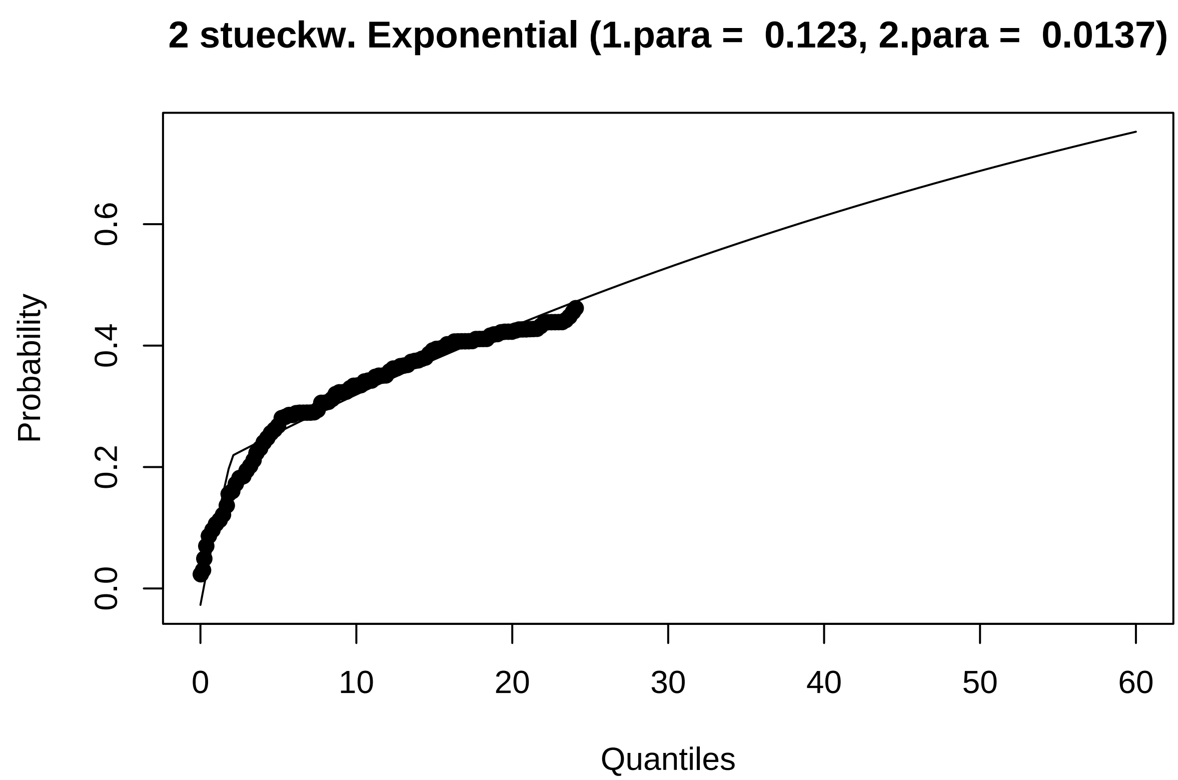
2-Stufige Exponetialverteilung

```r
# 2-Stufige Exponetialverteilung
source("C:/Users/Chau/Documents/Masterarbeit/R Funktionen/getstuexp2.R")

best_stuexp2_xr_makkar2012 <- find_best_start_2parameter(p = yr_makkar2012/100,
                                                         q = xr_makkar2012,
                                                         max_beta = 1,
                                                         max_eta = 0.5,
                                                         steps_beta = 0.1,
                                                         steps_eta = 0.01,
                                                         fitting_function = getstuexp2)
```

```
## Bester Startparameter: 0.8 0.08
## Bester Fehler: 3.724591e-06
```

```
stuexp2_xr_makkar2012 <- getstuexp2(
                        p = yr_makkar2012/100,
                        q = xr_makkar2012,
                        start = best_stuexp2_xr_makkar2012,
                        show.output = TRUE,
                        plot = TRUE,
                        wert1 = 2
                      )
```

```
## $par
## [1] 0.12303009 0.01373029
##
## $value
## [1] 3.724591e-06
##
## $counts
## function gradient
##       48       48
##
## $convergence
## [1] 0
##
## $message
## [1] "CONVERGENCE: REL_REDUCTION_OF_F <= FACTR*EPSMCH"
```

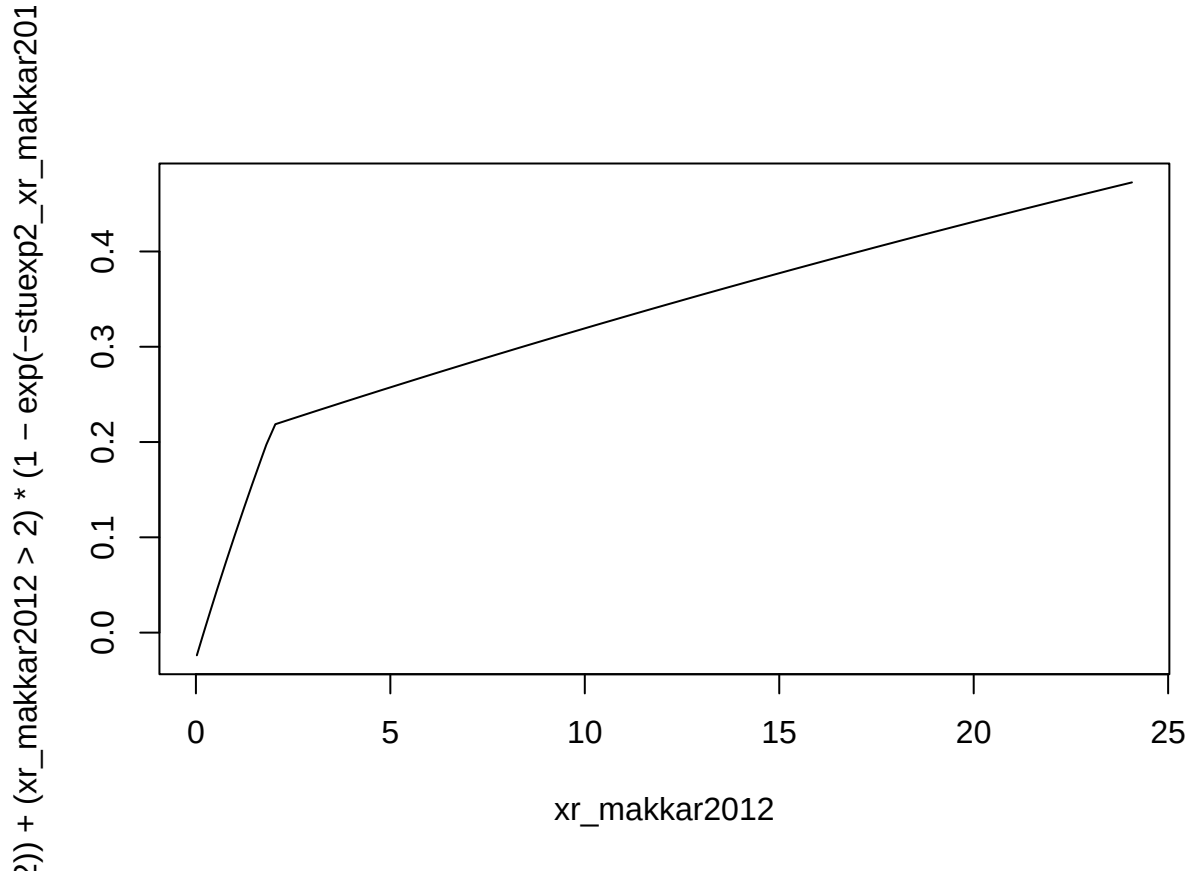


., 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

```
stuexp2_xr_makkar2012
```

```
##     1.para     2.para
## 0.12303009 0.01373029
```

```
plot(xr_makkar2012,
     ((xr_makkar2012 > 0 & xr_makkar2012 <= 2 ) * (1 - exp(-stuexp2_xr_makkar2012[1] * xr_makkar2012)) +
                                    (xr_makkar2012 > 2 ) *  (1 - exp(-stuexp2_xr_makkar2012[1] * 2))  +
                                    (exp(-2 * stuexp2_xr_makkar2012[2]) -
                                             exp(-stuexp2_xr_makkar2012[2] * xr_makkar2012))),
     type = "l")
```



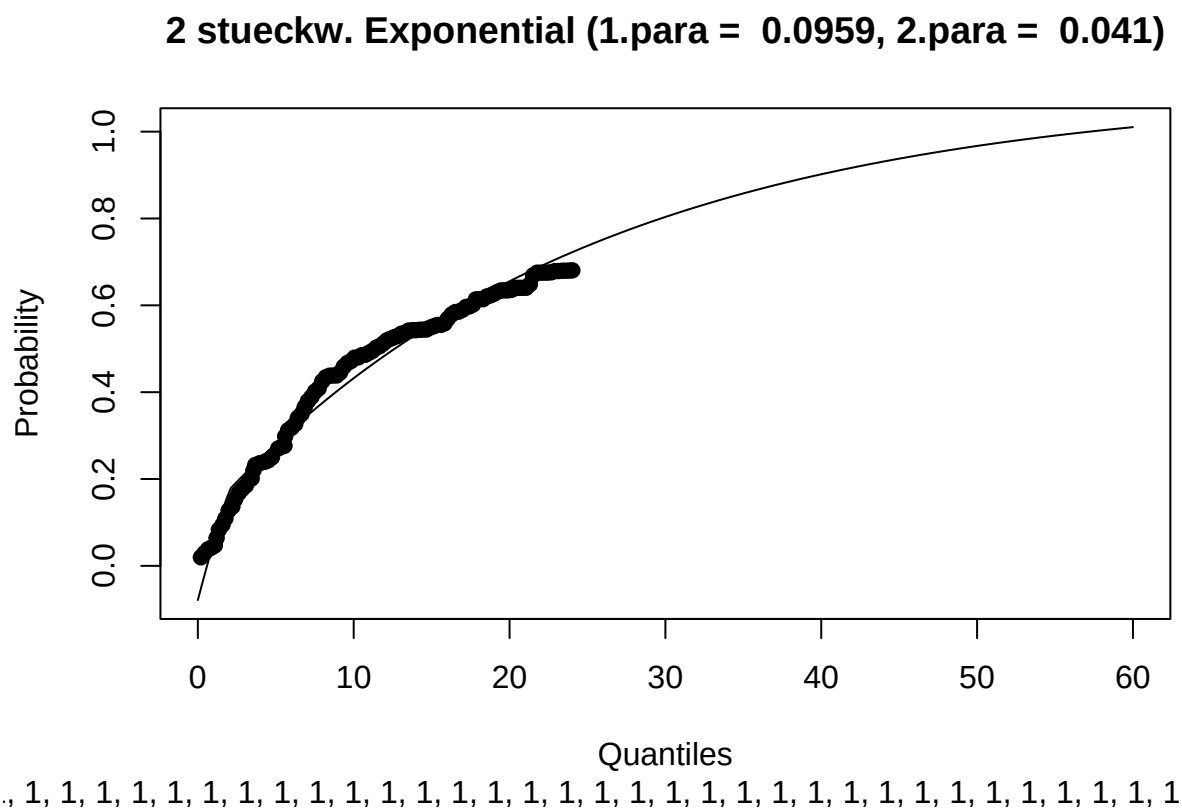

```
best_stuexp2_xb_makkar2012 <- find_best_start_2parameter(p = yb_makkar2012/100,
                                                         q = xb_makkar2012,
                                                         max_beta = 1,
                                                         max_eta = 0.5,
                                                         steps_beta = 0.1,
                                                         steps_eta = 0.01,
                                                         fitting_function = getstuexp2)
```

```
## Bester Startparameter: 0 0.45
## Bester Fehler: 6.948318e-06
```

```
stuexp2_xb_makkar2012 <- getstuexp2(
                        p = yb_makkar2012/100,
                        q = xb_makkar2012,
                        start = best_stuexp2_xb_makkar2012,
```

```
                        show.output = TRUE,
                        plot = TRUE,
                        wert1 = 2
                      )
```

```
## $par
## [1] 0.09588154 0.04100819
##
## $value
## [1] 6.948318e-06
##
## $counts
## function gradient
##       61       61
##
## $convergence
## [1] 52
##
## $message
## [1] "ERROR: ABNORMAL_TERMINATION_IN_LNSRCH"
```

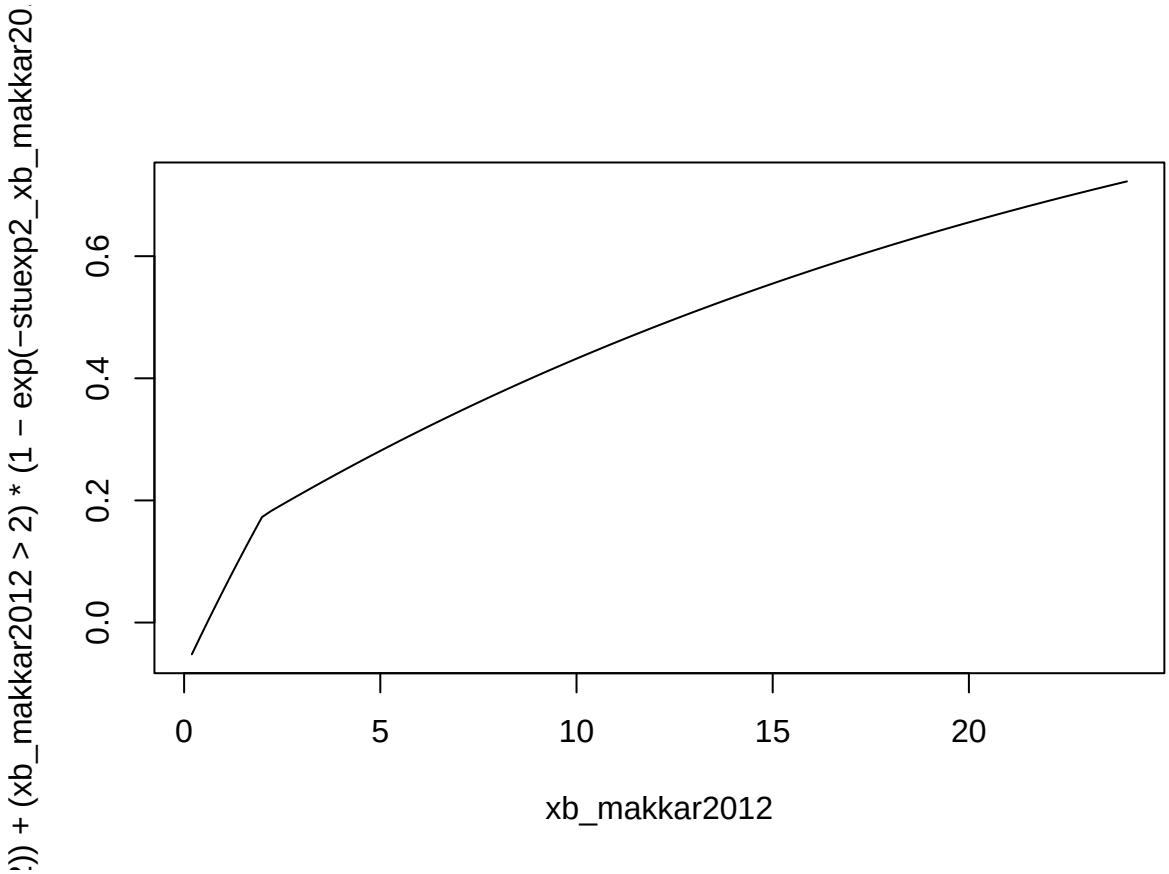


., 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

```
stuexp2_xb_makkar2012
```

```
##     1.para     2.para
## 0.09588154 0.04100819
```

```
plot(xb_makkar2012,
     ((xb_makkar2012 > 0 & xb_makkar2012 <= 2 ) * (1 - exp(-stuexp2_xb_makkar2012[1] * xb_makkar2012)) +
                                    (xb_makkar2012 > 2 ) *  (1 - exp(-stuexp2_xb_makkar2012[1] * 2))  +
                                    (exp(-2 * stuexp2_xb_makkar2012[2]) -
                                            exp(-stuexp2_xb_makkar2012[2] * xb_makkar2012))),
     type = "l")
```



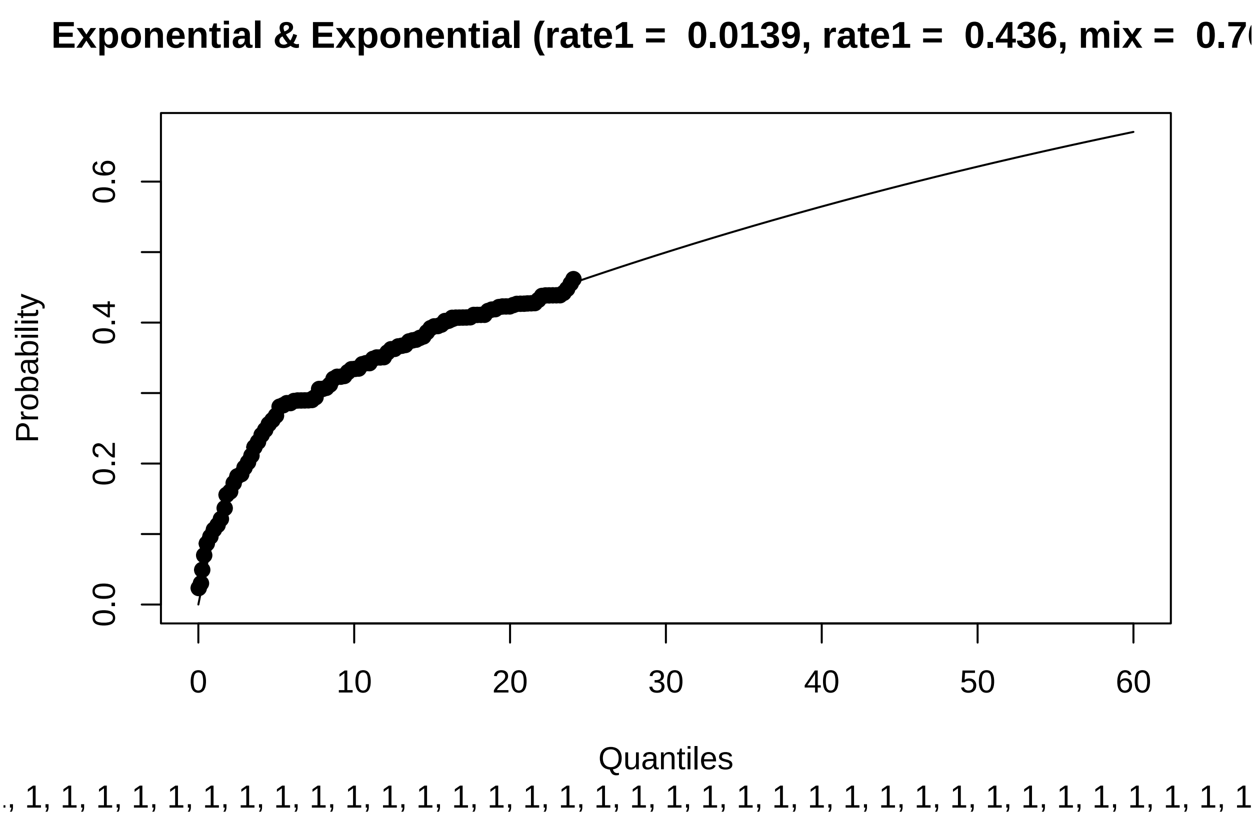
Mischung aus 2 Exponentialverteilungen

```
# Mischung aus 2 Exponentialverteilungen
source("C:/Users/Chau/Documents/Masterarbeit/R Funktionen/getexex.R")

best_exex_xr_makkar2012 <- find_best_start_3parameter(p = yr_makkar2012/100,
                                                      q = xr_makkar2012,
                                                      max_shape1 = 0.7,
                                                      max_shape2 = 0.7,
                                                      max_scale = 1,
                                                      steps_shape1 = 0.1,
                                                      steps_shape2 = 0.1,
                                                      steps_scale = 0.1,
                                                      fitting_function = getexex)
```

```
## Bester Startparameter: 0.2 0.6 0.6
## Bester Fehler: 6.101324e-07
```

```
exex_xr_makkar2012 <- getexex(
                        p = yr_makkar2012/100,
                        q = xr_makkar2012,
                        start = best_exex_xr_makkar2012,
                        show.output = TRUE,
                        plot = TRUE
                      )
```

```
## $par
## [1] 0.01392891 0.43649006 1.15260334
##
## $value
## [1] 6.101324e-07
##
## $counts
## function gradient
##       32       32
##
## $convergence
## [1] 0
##
## $message
## [1] "CONVERGENCE: REL_REDUCTION_OF_F <= FACTR*EPSMCH"
```

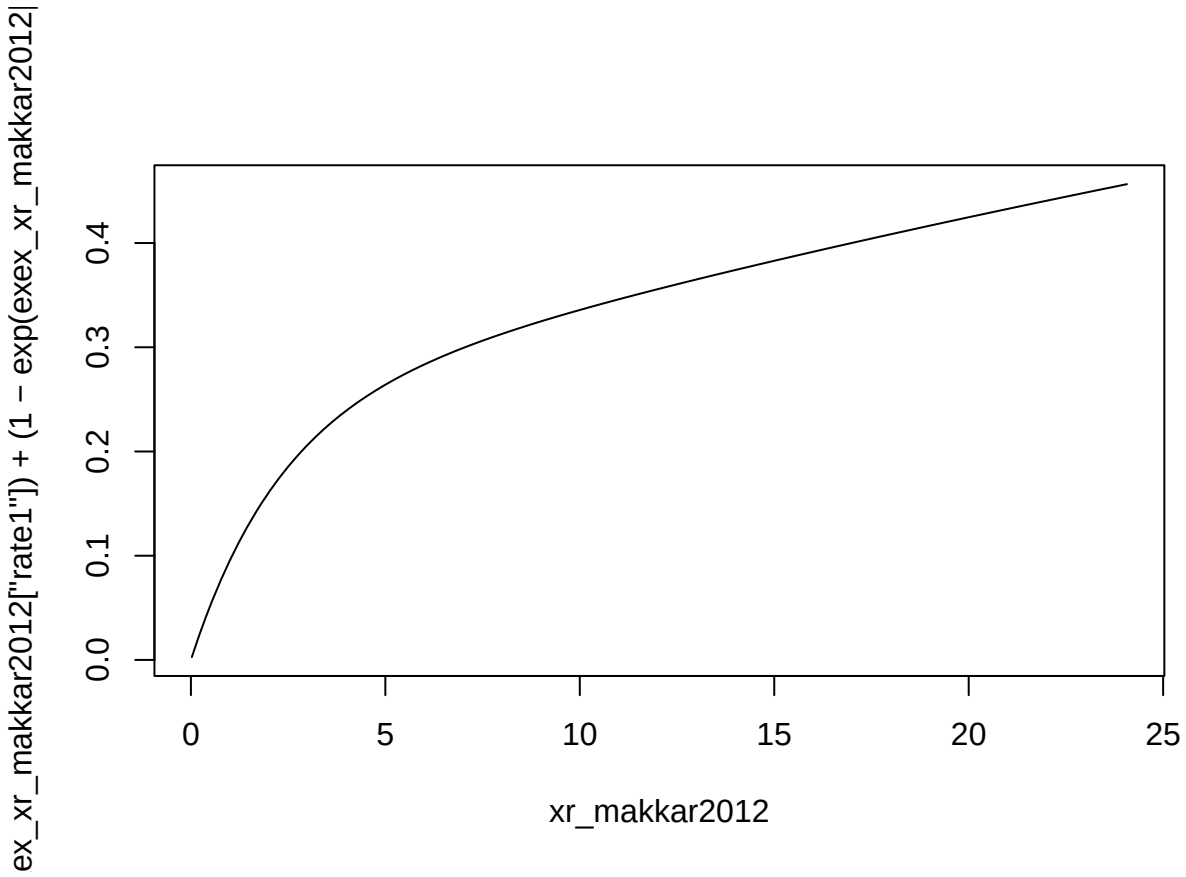



```
exex_xr_makkar2012
```

```
##      rate1      rate2        mix
```

```
## 0.01392891 0.43649006 1.15260334
```

```
plot(xr_makkar2012,
     (exp(exex_xr_makkar2012["mix"]) / ( 1 + exp(exex_xr_makkar2012["mix"])) *  stats::pexp(q = xr_makka
                                                                                  rate = exex_xr_makkar2012["
                      (1 - exp(exex_xr_makkar2012["mix"]) / ( 1 + exp(exex_xr_makkar2012["mix"]))) *
              stats::pexp(q = xr_makkar2012,
                          rate = exex_xr_makkar2012["rate2"])),
     type = "l")
```



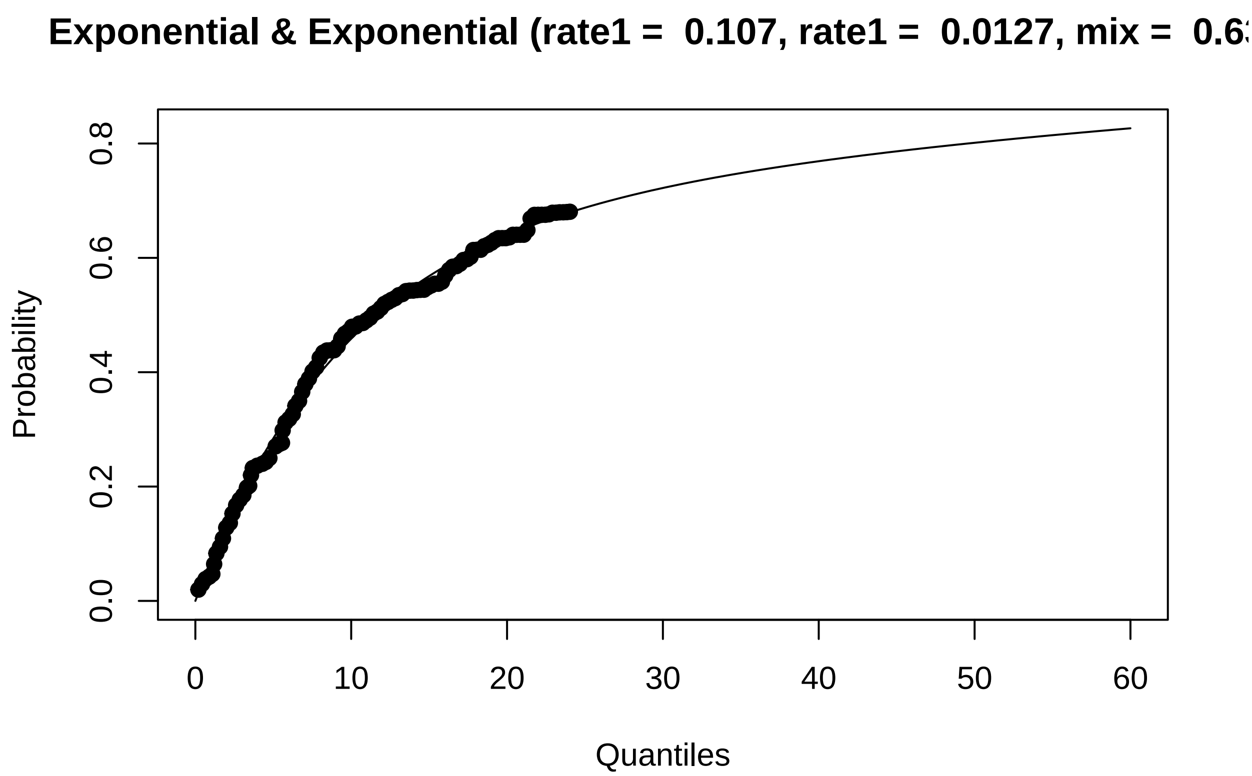

```
best_exex_xb_makkar2012 <- find_best_start_3parameter(p = yb_makkar2012/100,
                                                      q = xb_makkar2012,
                                                      max_shape1 = 0.7,
                                                      max_shape2 = 0.7,
                                                      max_scale = 1,
                                                      steps_shape1 = 0.1,
                                                      steps_shape2 = 0.1,
                                                      steps_scale = 0.1,
                                                      fitting_function = getexex)
```

```
## Bester Startparameter: 0.4 0.1 0.7
## Bester Fehler: 1.454402e-06
```

```
exex_xb_makkar2012 <- getexex(
                        p = yb_makkar2012/100,
                        q = xb_makkar2012,
                        start = best_exex_xb_makkar2012,
                        show.output = TRUE,
```

```
                        plot = TRUE
                      )
```

```
## $par
## [1] 0.10710580 0.01271255 0.53388168
##
## $value
## [1] 1.454402e-06
##
## $counts
## function gradient
##       21       21
##
## $convergence
## [1] 0
##
## $message
## [1] "CONVERGENCE: REL_REDUCTION_OF_F <= FACTR*EPSMCH"
```



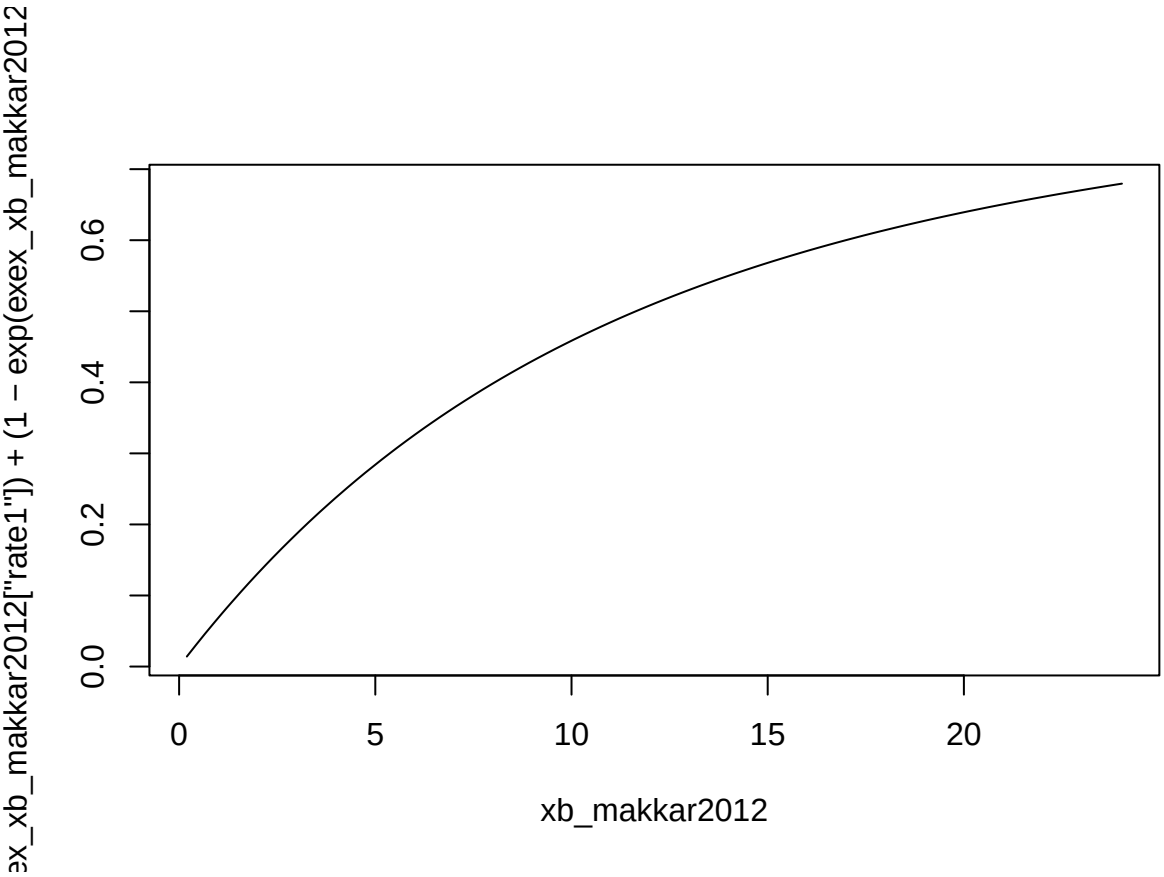
., 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

```
exex_xb_makkar2012
```

```
##      rate1      rate2        mix
## 0.10710580 0.01271255 0.53388168
```

```
plot(xb_makkar2012,
     (exp(exex_xb_makkar2012["mix"]) / ( 1 + exp(exex_xb_makkar2012["mix"])) *  stats::pexp(q = xb_makka
                                                                                  rate = exex_xb_makkar2012["
```

```
                    (1 - exp(exex_xb_makkar2012["mix"]) / ( 1 + exp(exex_xb_makkar2012["mix"]))) *
            stats::pexp(q = xb_makkar2012,
                        rate = exex_xb_makkar2012["rate2"])),
    type = "l")
```



Ergebnnis

```
getvalue <- function(p, q, best_start, fitting_function){
  if(identical(as.character(substitute(fitting_function)), "getstuexp2")){
    output <- capture.output({
    result <- getstuexp2(p = p, q = q, start = best_start, show.output = TRUE,
                         plot = FALSE, wert1 = 2)
    })
  }
  else if(identical(as.character(substitute(fitting_function)), "getstuexp3")){
          output <- capture.output({
            result <- getstuexp3(
                          p = p, q = q, start = best_start,
                          show.output = TRUE, plot = FALSE, wert1 = 2, wert2 = 6)
          })
  }
  else{
    output <- capture.output({
    result <- fitting_function(p = p, q = q, start = best_start,
```

```
                                show.output = TRUE, plot = FALSE)
    })
  }

  # Berechne den Fehler (makkar2012_r_1$value) für die aktuellen Startparameter
  error <- as.numeric(gsub("\\[1\\]\\s+", "", output[5]))

  return(error)
}

best_test <- function(p, q, weibull, weib, weibex, weibex2, expweib, stuexp3, stuexp2,
                      exex, start_weibull, start_weib, start_weibex, start_weibex2,
                      start_expweib, start_stuexp3, start_stuexp2, start_exex,
                      group){
  weibull_val <- getvalue(p, q, start_weibull, getweibullpar)
  weib_val <- getvalue(p, q, start_weib, getweibpar)
  weibex_val <- getvalue(p, q, start_weibex, getweibex)
  weibex2_val <- getvalue(p, q, start_weibex2, get2weibex)
  expweib_val <- getvalue(p, q, start_expweib, getexpweib)
  stuexp3_val <- getvalue(p, q, start_stuexp3, getstuexp3)
  stuexp2_val <- getvalue(p, q, start_stuexp2, getstuexp2)
  exex_val <- getvalue(p, q, start_exex, getexex)

  error_distribution_pairs <- list(
    list(weibull_val, "W"),
    list(weib_val, "e.W."),
    list(weibex_val, "M. W&E"),
    list(weibex2_val, "M. e.W&E"),
    list(expweib_val, "e.W o. lambda = 1"),
    list(stuexp3_val, "3 s.E."),
    list(stuexp2_val, "2 s.E."),
    list(exex_val, "M. E&E")
  )

  # Suchen Verteilung mit dem kleinsten Fehler
  best_pair <- error_distribution_pairs[[which.min(sapply(
    error_distribution_pairs, function(pair) pair[[1]]))]]

  # Drucken Sie die Ergebnisse
  cat("Beste Verteilung:", best_pair[[2]], "\n")
  cat("Bester Fehler:", best_pair[[1]], "\n")
  cat("Gruppe: ", group)

  return(c(group, best_pair[[2]],  best_pair[[1]]))
}

best_savr <- best_test(yb_makkar2012/100, xb_makkar2012, makkar2012_b_1, weibbull_xb_makkar2012,
                       weibex_xb_makkar2012, weibex2_xb_makkar2012, expweib_xb_makkar2012,
                       stuexp3_xb_makkar2012, stuexp2_xb_makkar2012, exex_xb_makkar2012,
                       best_makkar2012_b_1, best_weibbull_xb_makkar2012,
                       best_weibex_xb_makkar2012, best_weibex2_xb_makkar2012,
                       best_expweib_xb_makkar2012, best_stuexp3_xb_makkar2012,
                       best_stuexp2_xb_makkar2012, best_exex_xb_makkar2012, "SAVR")
```

```
## Beste Verteilung: M. e.W&E
## Bester Fehler: 1.221233e-06
## Gruppe:  SAVR
```

```
best_tavr <- best_test(yr_makkar2012/100, xr_makkar2012, makkar2012_r_1, weibbull_xr_makkar2012,
                       weibex_xr_makkar2012, weibex2_xr_makkar2012, expweib_xr_makkar2012,
                       stuexp3_xr_makkar2012, stuexp2_xr_makkar2012, exex_xr_makkar2012,
                       best_makkar2012_r_1, best_weibbull_xr_makkar2012,
                       best_weibex_xr_makkar2012, best_weibex2_xr_makkar2012,
                       best_expweib_xr_makkar2012, best_stuexp3_xr_makkar2012,
                       best_stuexp2_xr_makkar2012, best_exex_xr_makkar2012, "TAVR")
```

```
## Beste Verteilung: M. W&E
## Bester Fehler: 3.464472e-07
## Gruppe:  TAVR
```

```
tab <- matrix(c("PARTNER", "HiRi", "TS", best_tavr[1], best_tavr[2],
                best_tavr[3], NA, NA, weibex_xr_makkar2012[1:2], NA,
                weibex_xr_makkar2012[3:4],
                "PARTNER", "HiRi", "TS",  best_savr[1], best_savr[2],
                best_savr[3], weibex2_xb_makkar2012[1:3], NA, NA, NA,
                weibex2_xb_makkar2012[4],
                "PARTNER", "HiRi", "TS", best_savr[1], "M. W&E",
                getvalue(yb_makkar2012/100, xb_makkar2012, best_weibex_xb_makkar2012, getweibex),
                NA, NA, weibex_xb_makkar2012[1:2], NA,
                weibex_xb_makkar2012[3:4]),
              ncol=13, byrow=TRUE)

rownames(tab) <- NULL
colnames(tab) <- c('Studie', 'PG', 'EP', 'GR', 'Verteilung', 'SSE', '$\\alpha$',
                   '$\\theta$', '$\\lambda_1$', '$\\lambda_2$', '$\\lambda_3$',
                   '$\\vartheta$', '$\\psi$')

results <- as.data.frame(tab)

# Speichern
write.table(results, "results_makkar2012.txt", sep = "\t", row.names = FALSE)

# Funktion zur Überprüfung von NA-Werten für Zeichenketten und numerische Werte
is_non_empty <- function(x) {
  return(!is.na(x) & x != "")
}

# Spalten mit mindestens einem nicht-NA-Wert ermitteln
nicht_leere_spalten <- colSums(sapply(results, is_non_empty)) > 0

# Konvertieren Sie die Tabelle in eine Markdown-Tabelle
print(results[, nicht_leere_spalten])
```

```
##    Studie   PG EP   GR Verteilung          SSE         $\\alpha$
## 1 PARTNER HiRi TS TAVR     M. W&E 3.464472e-07              <NA>
## 2 PARTNER HiRi TS SAVR   M. e.W&E 1.221233e-06 0.321986355006115
## 3 PARTNER HiRi TS SAVR     M. W&E 1.268416e-06              <NA>
##         $\\theta$      $\\lambda_1$     $\\lambda_2$      $\\vartheta$
## 1            <NA>  0.53899113160967 92.2423486621234 0.374199091636215
```

```
## 2 8.8302090145643 0.194606590979799             <NA>              <NA>
## 3            <NA>  1.10083119741934 7.56464411964576 0.019962951660461
##            $\\psi$
## 1 2.11424198676707
## 2 1.00730812656599
## 3            0.001
```